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# Basal Metabolism of Young Women

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# BASAL METABOLISM OF YOUNG WOMEN

HUGHINA McKAY

## INTRODUCTION

Since the time of Lavoisier, who discovered the relation of oxygen to the heat production of the body, there have been many studies to determine the amount of heat produced by the body under various conditions. The greatest interest, however, has been attached to the heat production under basal conditions since this "represents the basic requirement of the human body to which the requirements for all other activities are added."

Basal metabolism may be defined as the energy metabolism of an organism when such metabolism is at its lowest point. Basal metabolism, therefore, is the energy production of a body at complete rest and in the post-absorptive condition because activity and ingestion of food both increase the energy production.

The basal heat production of the body, commonly termed basal metabolism, may be determined in two ways, either directly or indirectly. Through the use of the respiration calorimeter the amount of heat produced by the body may be measured directly. Respiration calorimeters, however, are costly to build and costly to operate; hence their use has been somewhat limited.

Less expensive in cost and simpler to operate are the various types of respiration apparatus by means of which the heat production of the body may be measured indirectly. Two general types of such apparatus in general use are the open and the closed circuit types.

With the open circuit type of respiration apparatus the subject inhales outdoor air. The expired air is collected in a gasometer, and a sample of this air is analyzed for carbon dioxide and oxygen. The calculation of the heat production of the body is based on the amount of carbon dioxide and oxygen found in the expired air.

When the closed circuit type of apparatus is used the subject breathes a measured amount of oxygen-rich air, and the carbon dioxide of the expired air is removed by soda lime. The oxygen which is used by the body is measured, and from the amount of oxygen used the energy production of the body is computed. Corrections must be made for temperature, atmospheric pressure, and humidity, and a constant respiratory quotient of 0.82 must be assumed, as is usually done when the oxygen consumption only is used as a basis for computing the heat production of the body.

More detailed discussions of basal metabolism and the types of apparatus used in measuring it may be found in references listed in the bibliography: Roth (1923), Boothby (1924), Du Bois (1927), and Lusk (1928).

Many studies have been made of the basal metabolism of individuals between 20 and 40 years of age, as well as that of infants and young children. Fewer observations have been made upon older children. Such studies as have been made of older children, and especially of young girls, are of somewhat recent date.

Benedict, Emmes, Roth, and Smith (1914) observed the basal metabolism of a large group of normal men and women and included in the number 7 girls from 15 to 18 years of age.

Benedict and Talbot (1921), as part of a large series of observations on younger children, reported 10 observations on girls from 10 to 13 years of age.

Benedict and Hendry (1921) and Benedict (1923) observed the energy production of groups of Girl Scouts who came to the Nutrition Laboratory in Boston in the afternoon and slept in a respiration chamber during the night. These groups ranged from 12 to 18 years of age, and every group but one consisted of 12 members, all seemingly in good physical condition. Basal energy production figures were obtained during the time when the girls were sound asleep. The figures were based upon the heat production of the group as a whole and therefore represent average values. The variation in basal metabolism from individual to individual could not be observed in the use of this group method.

Bedale (1923), in England, observed the basal metabolism of a number of children, among them girls from 9 to 17 years of age. Her observations were made before the children got out of bed in the morning.

Mac Leod (1924) reported the result of 362 determinations of the basal metabolism of 43 normal healthy girls from 11 to 14 years of age obtained by use of a Sanborn-Benedict Portable Respiration Apparatus.

Sandiford and Harrington (1925) gave a preliminary report on the basal metabolism of 157 school children of normal physical condition between the ages of 5 and 17.

Blunt et al. (1926) published the report of a study of basal metabolism of girls ranging in age from 8 to 18 years with the greater number between 9 and 13. The Benedict Portable Respiration Apparatus was used in this study.

Wang et al. (1926) reported the basal metabolism of 9 normal and 32 undernourished children from 4 to 13 years of age.

Benedict and Gustafson (1928), in a study of seasonal variation in basal metabolism, included young college women from 18 to 21 years of age.

Topper and Mulier (1929) reported the results of observations of the basal metabolism of 35 overweight, but otherwise normal, girls ranging in age from 6 to 14 and of a corresponding number of underweight girls ranging in age from 5 to 14 years.

Hitchcock and Wardwell (1929) reported a study of cyclic variations in the basal metabolic rate of college women and also considered the effect of season upon the basal metabolism.

Tilt (1930) published results of observations of basal metabolism of young college women in Florida. These young women were from 17 to 25 years of age, with the greater number 19 and 20.

Reference will be made to these studies throughout this report. For the period between 14 and 18 years of age there have been very few individual observations of the basal metabolism of young girls. It seemed worth while, therefore, to study the basal energy production of girls of these ages in order to determine average figures for each age group, as well as to determine the range from individual to individual. The results of such a study are reported in this paper.

The question of the variability of the basal metabolism of an individual from day to day led to the study of day by day variations of the basal metabolism of young women; this is also herein reported.

## EXPERIMENTAL

### APPARATUS AND METHOD

**Apparatus.**—The Benedict-Roth Metabolism Apparatus, which is a modification of the Benedict Portable Respiration Apparatus, was used in the study here reported.

This apparatus differs from the Benedict Portable Respiration Apparatus only in that rubber flutter valves replace the electric air blower. With either apparatus the amount of oxygen used is determined. Diagram 1 shows graphically the construction of the apparatus used. See also Figure 1.

In the use of this apparatus the subject is attached by means of a rubber mouth piece to a circuit in which there is a circulating stream of oxygen-rich air. During a test the nostrils are closed with a nose clip so that no air is breathed save that of the circuit.

As the subject breathes this oxygen-rich air from the spirometer chamber, oxygen is absorbed by the lungs while the expired air passes through the container of soda lime. The carbon dioxide is thus removed. As the oxygen is used by the body, the spirometer bell falls and the change in level indicates the amount of oxygen used. With this apparatus, instead of determining the amount of oxygen used by reading the millimeter scale at the side of the

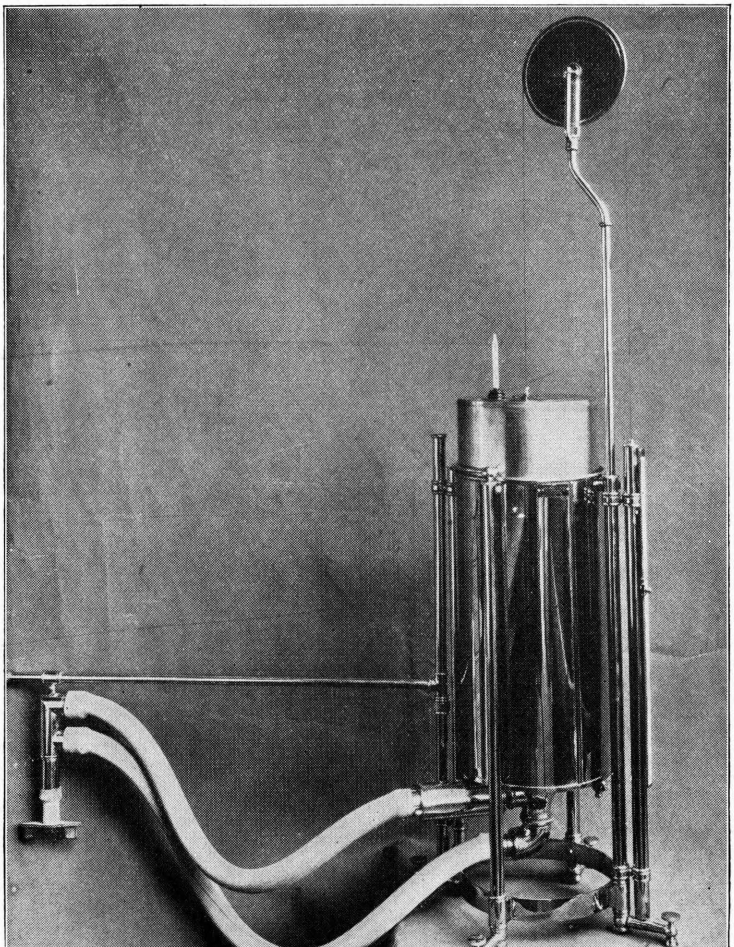

**Fig. 1.—Benedict-Roth respiration apparatus**
Courtesy Dr. Paul Roth

spirometer, a kymograph is attached, and a graphic record of the excursions of the spirometer bell is made.

**Subjects.**—Young women students of the Ohio State University formed the larger part of the 17- and 18-year groups. Through the cordial cooperation of Esther Allen Gaw, Dean of Women, many of the young women were interested in the project. A few of the 16-year-olds were college women, but in the main the

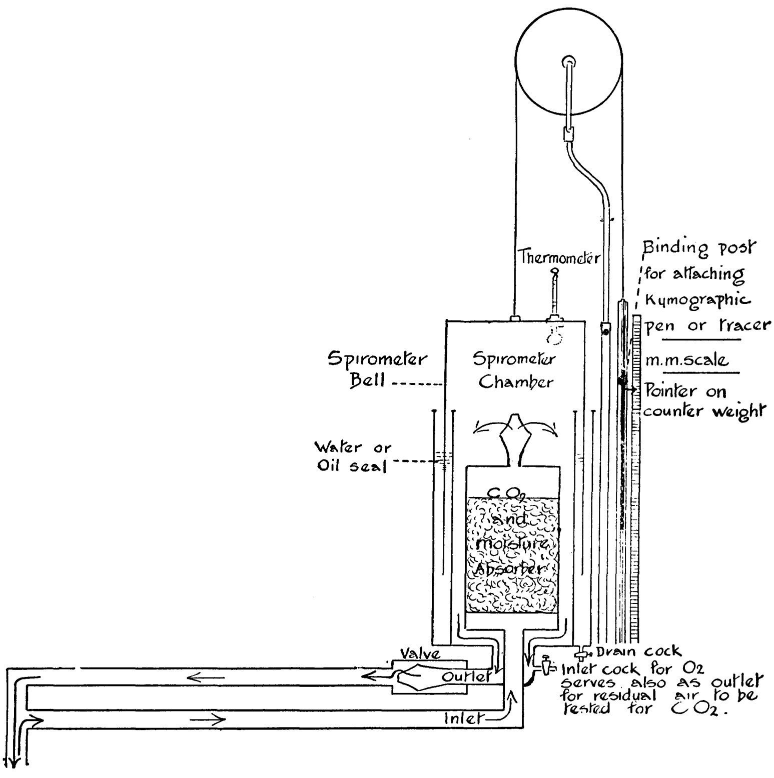


**Diagram 1.—Diagram of the Benedict-Roth respiration apparatus**
Adapted from The Boston Medical and Surgical Journal, April 1922. Courtesy of Dr. Paul Roth

14-, 15-, and 16-year groups were composed of volunteers from among the Girl Scouts of Columbus. The inconvenience of coming to the laboratory before breakfast, the length of time needed for the observations, and the fact that practically all the younger girls attended high school and were required to be there at 8:30 A. M. made securing subjects for these ages rather difficult. The most successful point of contact was made through the local Girl Scout organization.

The young girls who came to the laboratory before breakfast, rested a half hour or more, and had duplicate observations of their oxygen consumption taken before they had any food deserved the credit for community service which was given them.

Much credit is also due several 4H-Club girls who volunteered as subjects during achievement week on the campus.

**Physical condition of the subjects.**—All the girls for whom observations are reported were apparently normal. They were in good health and were active in school and in other organizations. In the case of the University students, medical examinations had been made, and all those who served as subjects were reported to be in good physical condition. With a number of the subjects observations were made in 1926 and also in 1927. In such cases, each girl was considered as two individuals in accordance with the principle stated by Benedict (1921): "The basal metabolism of an adult as measured from month to month and from year to year does not vary greatly as a result of a change in age and there is usually in this time no material change in weight and height. With children, on the other hand, the rapid growth and changes in stature and weight make it wholly illogical to average the values found for any child during a considerable range in age and to consider that the result represents the true average value for that child." This is true with these older children. The girl of 16 with a surface area of 1.57 square meters may be considered a different individual than the same girl of 14 with a surface area of 1.53 square meters.

Standing height, in stocking feet, and nude weight were taken for each girl. Two per cent of the net weight was added to the nude weight for comparison with the Baldwin-Wood standards since these standards are for girls in indoor clothing (Baldwin and Wood, 1926). All girls who were within a range of 10 per cent above or below the standard of weight for height were considered normal. Of the group of 91 girls included in the study here reported, 63 girls, or 69 per cent, could be considered normal according to this standard. Of the remaining 28, 19 girls, or 21 per cent of the entire group, were overweight, and 9 girls, or 10 per cent of the entire group, were underweight.

Average heights and weights for each age group were also computed for comparison with standard average heights and weights as given by Baldwin and Wood. For this comparison the average figure as given for girls of medium height has been used. As shown in Table 1 the average heights and weights of the groups of girls studied were well above the Baldwin and Wood standard for each age group except for the 16-year-olds, who averaged 2.6 centimeters and 0.2 kilogram below the standard—not a very significant difference.

**TABLE 1.—Comparison of Weight and Height of the Ohio Girls With Baldwin and Wood Standard***

| Age | Average height | | Average weight | |
|---|---|---|---|---|
| | Standard | Ohio girls | Standard | Ohio girls |
| *Yr.* | *Cm.* | *Cm.* | *Kg.* | *Kg.* |
| 14 | 157.5 | 158.0 | 49.9 | 50.3 |
| 15 | 160.0 | 162.0 | 52.6 | 53.6 |
| 16 | 162.6 | 160.0 | 54.3 | 54.1 |
| 17 | 162.6 | 162.0 | 55.3 | 56.1 |
| 18 | 162.6 | 164.0 | 55.8 | 59.9 |

*Standard: Average weight and height of girls of medium size as given by Baldwin and Wood.

As compared with average heights and weights for each age group of Benedict's Girl Scouts, however, the situation differs somewhat. As shown in Table 2 in which figures for nude weights are used, the 14-, 16-, and 17-year-old groups of Benedict's subjects were somewhat heavier than the Ohio girls of those ages. On the other hand, Mac Leod's 14-year-old girls averaged almost the same in height and weight as the 14-year-old girls reported in this study. It would seem, therefore, that the girls whose basal metabolism is being reported in this paper should be considered normal as far as the weight-height-age index is concerned.

**TABLE 2.—Comparison of Height, Weight, and Surface Area of Girls***

| Age | Weight | | | Height | | | Surface area | | |
|---|---|---|---|---|---|---|---|---|---|
| | Boston Girl Scouts | Mac Leod | Ohio girls | Boston Girl Scouts | Mac Leod | Ohio girls | Boston Girl Scouts | Mac Leod | Ohio girls |
| *Yr.* | *Kg.* | *Kg.* | *Kg.* | *Cm.* | *Cm.* | *Cm.* | *Sq. M.* | *Sq. M.* | *Sq. M.* |
| 14 | 51.0 | 49.5 | 49.3 | 159 | 158 | 158 | 1.51 | 1.48 | 1.48 |
| 15 | 49.9 | ........ | 52.5 | 160 | ........ | 162 | 1.51 | ........ | 1.55 |
| 16 | 53.6 | ........ | 53.0 | 163 | ........ | 160 | 1.57 | ........ | 1.54 |
| 17 | 58.1 | ........ | 55.0 | 163 | ........ | 162 | 1.62 | ........ | 1.57 |
| 18 | 57.2 | ........ | 58.7 | 165 | ........ | 164 | 1.62 | ........ | 1.63 |

*Based on three studies.

In making the observations no effort was made either to include or to avoid menstrual period. A record to indicate whether or not menstruation was taking place was kept, however. As a matter of interest, it may be stated that very few records, only nine, were made during menstruation. Moreover, in practically all of the nine cases, only one of the two or three observations was made during the period. The influence of menstruation on the results as reported in this study must be, therefore, very slight.

As a part of the general study of basal metabolism of young women, 5 upperclass students of the School of Home Economics volunteered as subjects for a study of day by day variations in basal metabolism. Of these five young women, two were 21, two were 22, and one was 24 years old. All were in good physical condition. Observations on these subjects extended from October, 1926 to June, 1927. Each of the young women served as a subject for approximately one school quarter with observations made practically every day except Sunday.

**Method of procedure.**—Before a record of her oxygen consumption was made the procedure was explained to each subject so that she was not entirely unfamiliar with the method to be followed. In many cases a preliminary test was made to acquaint the young woman with the apparatus. On each day appointed for a test the subject came to the basal metabolism laboratory without breakfast. Before the observation was begun, she rested lying on a bed, mentally and physically relaxed, and comfortably warm for from 30 to 40 minutes. During this period of rest the body temperature was taken by mouth, the pulse was taken several times, and the respiration was counted. On such few occasions as a temperature above normal was found the subject was dismissed until such a time as the temperature was found to be normal because it has been shown that increased temperature is accompanied by a heat production above normal (Boothby, 1924).

While the subject was resting, the spirometer chamber was partially filled with oxygen, the apparatus was tested for leaks, and the paper for the graphic record was placed on the drum of the kymograph. At the conclusion of the rest period the subject was attached to the circuit and the nostrils were closed by use of the nose clip. During the 10-minute test which followed, the pulse was counted several times. At the end of from three to five minutes the apparatus was tested for leaks by placing a 50-gram weight on the spirometer bell. Any sudden pronounced change in the angle of the graph was taken to indicate a leak. In case a leak was found the subject was released from the apparatus, and the cause of the leak determined before the test was resumed.

At the conclusion of a 10-minute test the subject was allowed to rest for a minute or two, the spirometer chamber was refilled with oxygen, and a second test was made. If a result which agreed within 5 per cent with the first test was secured, the lowest finding of the two observations was taken as the basal metabolism rate, for as Benedict says: "If in any series of measurements a period of complete repose gives us a value for the oxygen consumption or carbon dioxide production that is lower than all the other period values, then, if technical errors have been avoided, this period must closely approximate the basal metabolism." (Benedict, 1924).

In every case observations were repeated on a second and in some cases a third occasion so that each value given for oxygen consumption represents the average of the lowest figures for which a satisfactory check was obtained on two or more successive days.

Routine tests for unabsorbed carbon dioxide were made each day. Wilson's soda lime was used as the carbon dioxide absorber and was renewed as frequently as was necessary to keep it effective.

Data are given in the following pages for 91 subjects for whom two or more observations were made, and for 5 subjects for each of whom from 23 to 47 consecutive observations were made. Age in all cases is recorded as that of the nearest birthday.

## RESULTS

Table 1 (Appendix) presents the fundamental data concerning the heat production of 91 girls from 14 to 18 years of age. In Table 3 is given the average heat production as computed for each age group on the basis of total calories, calories per kilogram, and calories per centimeter per 24 hours, as well as calories per square meter per hour.

**TABLE 3.—Average Heat Production of 91 Girls From 14 to 18 Years of Age**

| Age of subjects | No. of subjects | No. of observations reported | Calories per 24 hours | Calories per kg. per 24 hours | Calories per cm. per 24 hours | Calories per sq. m. per hour |
|---|---|---|---|---|---|---|
| *Yr.* | | | | | | |
| 14 | 7 | 18 | 1340 | 27.3 | 8.4 | 37.7 |
| 15 | 17 | 43 | 1388 | 26.6 | 8.6 | 37.4 |
| 16 | 20 | 50 | 1326 | 25.2 | 8.3 | 36.0 |
| 17 | 32 | 84 | 1381 | 25.3 | 8.5 | 36.6 |
| 18 | 15 | 43 | 1365 | 23.4 | 8.3 | 34.8 |
| Average | 91 | 238 | 1364 | 25.4 | 8.4 | 36.4 |

### TOTAL HEAT PRODUCTION PER 24 HOURS

As shown by Table 3 the average total heat production per 24 hours is practically the same for the five age groups considered. This was approximately 1350 calories. Results of other studies have shown a corresponding similarity. In commenting on this similarity of results for Bedale's, Mac Leod's, and the Boston Girl

Scout studies, Benedict (1924) says: "Thus 3 independent series of measurements are in agreement in the finding that metabolism is essentially constant with girls from 12 to 18 years of age, i. e., independent of weight, height or age."

In Table 4 findings from the three studies referred to by Benedict, as well as findings from the more recent studies of Blunt (1926), Benedict and Gustafson (1928), and Tilt (1930) are brought together for comparison with the results of the Ohio study.

**TABLE 4.—Average Basal Heat Production per 24 Hours as Shown in Age Groups***

| Study | Age 14 years | | Age 15 years | | Age 16 years | | Age 17 years | | Age 18 years | |
|---|---|---|---|---|---|---|---|---|---|---|
| | No. of subjects | Cal. per 24 hr. | No. of subjects | Cal. per 24 hr. | No. of subjects | Cal. per 24 hr. | No. of subjects | Cal. per 24 hr. | No. of subjects | Cal. per 24 hr. |
| Benedict's Girl Scouts | 12 | 1314 | 12 | 1254 | 11 | 1170 | 12 | 1258 | 12 | 1253 |
| MacLeod | 13 | 1308 | ........ | ........ | ........ | ........ | ........ | ........ | ........ | ........ |
| Blunt | 3 | 1380 | 2 | 1498 | 2 | 1317 | 3 | 1543 | 3 | 1406 |
| Bedale | ........ | ........ | 4 | 1456 | 5 | 1363 | 2 | 1348 | ........ | ........ |
| Benedict-Gustafson | ........ | ........ | ........ | ........ | ........ | ........ | ........ | ........ | 5 | 1391 |
| Tilt | ........ | ........ | ........ | ........ | ........ | ........ | 2 | 1126 | 6 | 1250 |
| This study | 7 | 1340 | 17 | 1388 | 20 | 1326 | 32 | 1381 | 15 | 1365 |

*Based on seven studies.

For age 14, Mac Leod's data as well as data for the Boston Girl Scouts are available for comparison. A comparison of average height, weight, and surface area of the three groups shows that the Ohio girls and the New York girls were practically the same (See Table 2) in height, weight, and surface area but that the Boston girls were taller, heavier, and had a larger surface area. The heat production of the three groups, however, differs little, each producing approximately 1300 calories daily. The greater weight and height of the Boston girls may account for the fact that although they were asleep at the time the observations were taken their total energy production was only slightly less than that of the somewhat lighter girls of the two other groups who were awake at the time of observation.

With a limited group of children, five boys and seven girls, from 4 to 10 years of age, Wang and her co-workers (1928) found decidedly lower values during sleep than when the children were awake and found that the sleeping values agreed more closely with the Benedict standards than the waking values. Griffith and co-workers (1928) report that for two men who were able to sleep during basal metabolism observations, so slight an effect was noticed that it might be considered negligible. They state, however, that the conclusions do not necessarily apply to the metabolism during prolonged, deep sleep.

For comparison of the results for the older girls, 15 to 18 years, the only data available, considering groups of somewhat similar size, are the results of Benedict's Girl Scout study. For the 15-, 16-, 17-, and 18-year-olds, the calorie production of the two groups differs more than for the 14-year-olds. Benedict's Girl Scouts average from 112 to 156 fewer calories for each age than do the Ohio girls. If sleep is the depressing influence it is hard to understand why it is not as effective in depressing metabolism at 14 years as in the succeeding years. The Ohio 15- and 18-year-olds average a larger surface area than do the 15- and 18-year Benedict Girl Scouts; at 16 and 17 they are larger than the Ohio girls, but there seems to be no consistent relationship here between difference in size and in calorie production.

For the 18-year group there is available for comparison the five 18-year-olds included in the Wellesley College study (1928). These young women were in a college environment and living under conditions probably quite similar to those under which the Ohio students lived. There was one difference in the method of collecting the data. The Wellesley College students slept in the laboratory the night preceding the test, and the observation of their heat production was made before they got out of bed in the morning. The Ohio students spent the night preceding the test at their accustomed places of residence, rose, dressed, came to the laboratory, and rested at least half an hour before their heat production was measured. That this difference in method is of little or no significance has been shown by Benedict and Crofts with older persons, and by Rose and Mac Leod with children.

Benedict and Crofts (1925) studied the heat production of eight persons, one man and seven women, first after resting quietly in bed during the night and second after bathing, dressing, walking for 10 minutes in the open air, and then resting one-half hour. As a result of this study they conclude that: "In the case of normal subjects the exercise of rising, bathing, dressing, walking, and mounting several flights of stairs is without influence upon the basal metabolism on any individual day, provided the usual rest period of one-half hour is insisted upon."

Working with children, Rose and Mac Leod (1926) came to the conclusion that: "It is immaterial whether the basal metabolism of a child is made before rising, in the bed where he has spent the night or after a rest period following the child's arrival at the laboratory in the morning after having spent the night in his own home."

As shown in Table 5 the average heat production of the 15 Ohio girls aged 18 and the average heat production of the 5 Wellesley girls aged 18 are almost identical, 1365 calories for the former as compared to 1391 calories for the latter, a difference of little or no significance.

In the group of college women of Florida whose basal metabolism was reported by Tilt (1930) are two 17-year-olds and six 18-year-olds. For both these age groups the total heat production is lower than that of the Ohio girls and more closely approaches that of Benedict's Girl Scouts. On the other hand, Tilt's young women were smaller in stature and in weight than either the group of Ohio girls or Benedict's Girl Scouts. Moreover, the low figures reported by Tilt may possibly indicate as she suggests, "that the basal metabolism of southern college women tends to be lower than that predicted for young women of the same age and living in the north."

## RANGE IN TOTAL HEAT PRODUCTION

Although the average figures for heat production differ little among the five age groups considered in the Ohio study, the difference in heat production from individual to individual is large. Surprisingly enough both highest and lowest heat production figures were found in the 18-year group. Number 86, whose heat production was the lowest of the entire group, averaged 1086 calories daily as compared to 1687 for Number 81, whose heat production was the highest of the 91 girls. In other words, of two girls of the same age one was producing slightly over half or 50 per cent more heat than the other. Reference to the fundamental data in Table 1 (Appendix) shows that somewhat smaller but decidedly wide ranges in total heat production per 24 hours are found in each of the other four age groups. The range in total calories per day for the 14-year-old group is from 1174 to 1516; for the 15-year-olds, 1119 to 1604; for the 16-year-olds, 1133 to 1591; and for the 17-year-olds, 1171 to 1668. These wide variations are associated with variations in size of the girls. Although Table 1 shows that the average height and weight of each group increases steadily and consistently as age increases, examination of weights and heights of individual girls shows that there is a wide variation in each age group. To illustrate, Number 49, one of the smallest, and Number 64, one of the largest of the girls, were both 17 years old.

As a means of predicting basal metabolism for girls from 14 to 18 years old, age in itself is of little value except that, in general, increased age is associated with increased stature and height.

Both Blunt's and Mac Leod's figures show a steady increase of calories with increasing age for their younger children, 9 to 13 years, but this trend is not noticeable with these older children nor was it the case with Benedict's Girl Scouts. It is possible that such increases as Blunt and Mac Leod report reach their height at 14 years, or thereabouts, and thereafter decrease.

## OVERWEIGHT AND UNDERWEIGHT IN RELATION TO HEAT PRODUCTION

Of the entire group of 91 girls, 19 were more than 10 per cent above, and 9 were more than 10 per cent below the Baldwin-Wood standards of weight for height and age. This left 63 members of the group in the "normal" zone. To compare the heat production of the entire group, the normals, the overweights, and the underweights, Table 5 was prepared. Although the average heat production of the 63 "normals" differs little from that of the entire group, (1346 calories for the normal weight group as compared to 1364 calories for the entire group), the overweights with an average of 1474 calories and the underweights with an average of 1262 calories, each differ from the group average by just about the same amount. The overweights average 8 per cent above and the underweights 7.5 per cent below the average for the entire group. Blunt (1926) has stressed the point that girls of abnormal build tend to deviate from the average in total heat production the values for the overweights being above and the values for the underweights below the average.

**TABLE 5.—Comparison of Average Heat Production per 24 Hours of Normals, Overweights, Underweights, and Entire Group**

| | No. of subjects | Average calories | | | |
|---|---|---|---|---|---|
| | | Total per day | Per kg. | Per cm. | Per sq. m. per hr. |
| Entire group | 91 | 1364 | 25.4 | 8.4 | 36.4 |
| Normals | 63 | 1346 | 25.7 | 8.3 | 36.4 |
| Overweights | 19 | 1474 | 23.0 | 9.0 | 36.2 |
| Underweights | 9 | 1262 | 28.4 | 7.9 | 37.0 |

Working with younger children (5-13 years of age) Wang (1926) found that basal metabolism decreases with increasing underweight. Topper and Mulier (1929), reporting observations on a large group of 70 underweight and 70 overweight children, conclude that "overweight but otherwise normal" children have a tendency toward a high normal rate, and the majority of underweight but otherwise normal children have a decided tendency toward a low normal rate. These latter authors state in regard to children what Benedict, Roth et al. state in regard to adults (1919) "that the basal metabolism depends on the nutritional condition of the cells, plethora acting as a stimulant and conversely inanition acting as a depressant to the basal metabolic rate—a mechanism, to a certain extent, compensatory for preventing excess of fat in the former case and staving off starvation in the latter."

### HEAT PRODUCTION AS REFERRED TO WEIGHT

As shown in the preceding paragraphs, age, as such, had little or no influence upon the heat production of the girls studied. The average heat production for all the age groups was practically the same, approximately 1350 calories daily. When heat production per kilogram of body weight was referred to age, however, there was found to be a decided relationship between the two. As age increased the calorie production per kilogram decreased in a fairly regular manner, from 27 calories per kilogram in the 14-year-olds to 23 calories per kilogram in the 18-year-olds. (See Table 3). The fact that the total heat production of the 18-year-olds was practically the same as that of the 14-year-olds, but the heat pro-

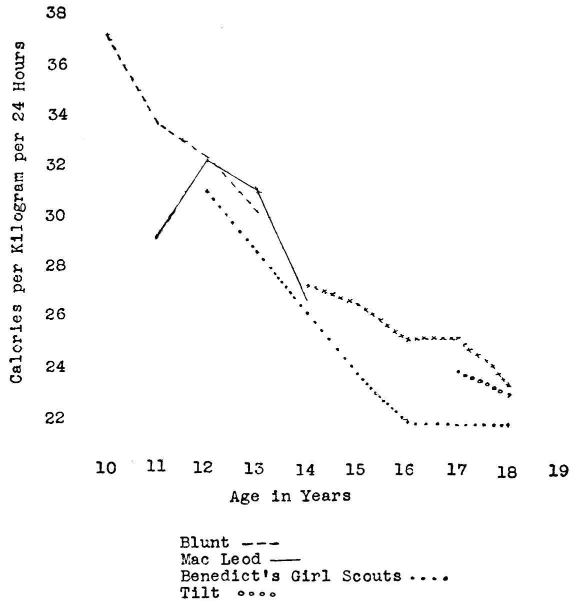


**Diagram 2.—Graph showing average heat production per kilogram per 24 hours for the different age groups**

duction per kilogram less, serves to emphasize the fact that as a group the older girls weighed more than the younger ones but metabolized somewhat more slowly. (See Table 1, which shows the average weight of the 18-year-olds to be 58.7 kilograms as compared to 49.3 kilograms for the 14-year-olds).

**TABLE 6.—Average Heat Production per Kilogram***

| | Blunt | MacLeod | Benedict's Girl Scouts | Tilt | This Study |
|---|---|---|---|---|---|
| 10 | 37.2 | ........... | ........... | ........... | ........... |
| 11 | 33.7 | 29.2 | ........... | ........... | ........... |
| 12 | 32.4 | 32.3 | 31.0 | ........... | ........... |
| 13 | 30.2 | 31.1 | 28.6 | ........... | ........... |
| 14 | ........... | 26.7 | 26.2 | ........... | 27.3 |
| 15 | ........... | ........... | 23.8 | ........... | 26.6 |
| 16 | ........... | ........... | 21.9 | ........... | 25.2 |
| 17 | ........... | ........... | 21.8 | 23.9 | 25.3 |
| 18 | ........... | ........... | 21.8 | 23.0 | 23.4 |

*Based on five studies.

Blunt's (1926) girls from 10 to 13 also produced less heat per kilogram as age increased. Her older girls, a much smaller group, did not show as regular a decrease per kilogram with age. From 12 to 14 years Mac Leod's girls also showed a decreasing heat production per kilogram with increasing age. Benedict's Girl Scouts decreased in heat production rather more rapidly per kilogram of body weight as age increased than did the Ohio girls. Tilt's 17-, 18-, and 19-year-old women showed a decreasing heat production per kilogram for each age group, (Table 6 and Diagram 2.) It seems safe to say that from 10 to 20 years of age heat production per kilogram decreases with age, and that age and weight together are serviceable as a basis for predicting basal metabolism of girls of these ages.

**TABLE 7.—Average Heat Production per 24 Hours Referred to Weight**

| Weight in kg. | No. of cases | Av. total calories | Av. cal. per kg. | Av. cal. per cm. | Av. cal. per sq. m. per hr. |
|---|---|---|---|---|---|
| 38–42 | 3 | 1223 | 30.0 | 8.1 | 38.7 |
| 42–46 | 7 | 1220 | 27.8 | 7.9 | 36.8 |
| 46–50 | 15 | 1329 | 27.7 | 8.4 | 37.7 |
| 50–54 | 22 | 1336 | 25.6 | 8.2 | 35.9 |
| 54–58 | 19 | 1367 | 24.6 | 8.4 | 35.9 |
| 58–62 | 14 | 1408 | 23.7 | 8.6 | 35.8 |
| 62–66 | 5 | 1522 | 24.0 | 9.3 | 37.5 |
| 66 and over* | 6 | 1552 | 21.6 | 9.2 | 35.5 |

*79.9 is limit of range.

In Table 7 age has been disregarded, and heat production in reference to weight has been computed. This table serves to bring out the fact that as weight increases, total calories as well as calories per centimeter also increase in a fairly regular manner.

The girls who weighed 38 to 42 kilograms averaged 1223 calories per 24 hours and 8.12 calories per centimeter as compared to 1552 calories per 24 hours and 9.19 calories per centimeter for girls who weighed 66 kilograms or more.

On the other hand, average calorie production per kilogram decreased in a decidedly regular manner as weight increased. The girls who weighed from 38 to 42 kilograms averaged 30 calories per kilogram as compared to 21.6 calories per kilogram for the girls who weighed 66 kilograms or more.

Heat production per square meter also decreased with the increasing weight, being 35.5 calories per hour for the heavier girls as compared to 38.7 calories per hour for the girls of lighter weight. This difference is slight, however, being only about one fourth as great as corresponding differences in heat production per kilogram, and the decrease is not as regular.

### HEAT PRODUCTION OF OVERWEIGHTS AND UNDERWEIGHTS AS REFERRED TO WEIGHT

Interestingly enough, the average heat production of the overweights as a group varied from the average of the entire group by 8 per cent on the basis of total calories and by —9 per cent on the basis of calories per kilogram. With the underweights the situation was the reverse. For them the corresponding average deviations were 7 per cent below and 12 per cent above (Table 5). These results substantiate the findings of Blunt (1926) that "underweights tend to have lower total calorie production but high calories per kilo as compared to the normal. The overweights on the other hand tend to have high total calories but low calories per kilo."

As shown by Table 7, therefore, weight alone gives a better basis for predicting basal metabolism of young girls than does age alone. According to Benedict and Talbot (1921), "The influence of weight far exceeds that of age."

That age and weight together may be serviceable in predicting the basal metabolism of young girls is shown in Table 3 in which the heat production per kilogram of weight is seen to decrease with age. As a result of analysis of the Girl Scout data, Benedict (1924) states that for "from 12 to 20 years of age, the metabolism of girls may at present be best predicted from the heat production per kilogram of body weight referred to age."

### HEAT PRODUCTION AS REFERRED TO HEIGHT

That the five age groups studied were more uniform in height than in weight is shown by the fact that although the 18-year-olds averaged only 3.7 per cent taller than the 14-year-olds, they were 19 per cent heavier. These averages for each age group mask greater individual differences within each age group however. For example, the tallest and shortest girls of the 14-year-olds measured 149 and 167 centimeters, respectively; of the 15-year-olds, 156 and 172; for the 16-year-olds, the figures were 149 and 172; for the 17-year-olds, 150 and 174; and for the 18-year-olds, 157 and 175. For these girls from 14 to 18 years of age, height seemed to have little direct relationship to age. The oldest girls were not the tallest nor the youngest girls the shortest of the group, and although the average of the 18-year group was greater than that of any of the other groups, the 15- and the 17-year-olds had an identical average, 162 centimeters. Moreover, variation in height of individual girls was much smaller than variation in weight. To illustrate, the heaviest girl weighed somewhat over twice as much as the girl who weighed the least; whereas the difference in height between the tallest and the shortest girl was only 17 per cent. Obviously the difference in heat production per centimeter was greater than the corresponding difference per kilogram.

As with total heat production, calories per centimeter differed little with age; the average for each of the ages studied being approximately the same as the average for the entire group (See Table 3). The greatest deviation from the group average of 8.4 calories per centimeter was for the 16-year-olds with an average deviation of only 1.5 per cent.

The fact that the total heat production of the 18-year-olds differed from that of the 14-year-olds by 1.8 per cent and the heat production per centimeter by 1.6 per cent must serve to emphasize the fact that height is a variable factor with girls from 14 to 18; that is, increases in height with girls of these ages are less uniform and consistent than increases in weight.

On the basis of heat production per centimeter there is an interesting agreement with the results of studies of younger girls. Blunt's girls (1926), 11 to 14 years, averaged 8.6 calories per centimeter; Mac Leod's girls (1924), 11 to 14 years, 8.8 calories per centimeter; and these Ohio girls, 14 to 18 years, 8.4 calories per centimeter. Average heat production per centimeter, therefore, may be considered as decreasing only slightly with age.

In Table 8 age has been disregarded, and heat production as referred to height has been computed. As shown by this table, total heat production per 24 hours increased regularly as stature increased, the taller girls, 170 to 175 centimeters, producing 1536 calories per 24 hours as compared to 1202 calories for a corresponding period by the shorter girls, 145 to 150 centimeters. Heat production per centimeter increased slightly but in a fairly regular manner as height increased, the taller girls producing 8.9 calories per centimeter as compared to 8.1 calories per centimeter by the shorter girls.

TABLE 8.—Average Heat Prodution per 24 Hours Referred to Height

| Height in cm. | No. of cases | Av. total calories | Av. cal. per kg. | Av. cal. per cm. | Av. cal. per sq. m. per hr. |
|---|---|---|---|---|---|
| 145–150 | 2 | 1202 | 28.1 | 8.0 | 37.7 |
| 150–155 | 7 | 1280 | 27.4 | 8.4 | 37.8 |
| 155–160 | 18 | 1308 | 25.9 | 8.3 | 36.6 |
| 160–165 | 40 | 1349 | 25.0 | 8.3 | 35.9 |
| 165–170 | 18 | 1447 | 25.0 | 8.7 | 36.6 |
| 170 and over* | 6 | 1536 | 24.1 | 8.9 | 36.4 |

*175 is limit of range.

On the other hand, average heat production per kilogram decreased as stature increased, the taller girls, 170 centimeters and more, producing 24.1 calories per kilogram as compared to 28.1 calories per kilogram produced by the shorter girls, 140 to 150 centimeters.

Heat production per square meter also decreased, but only slightly, as height increased. The shorter girls averaged 37.7 calories per square meter as compared to 36.4 calories per square meter for the taller girls.

## UNDERWEIGHT AND OVERWEIGHT AS INFLUENCING HEAT PRODUCTION AS REFERRED TO HEIGHT

Regardless of age, the underweights as a group averaged 7.9 calories per centimeter per 24 hours, a deviation from the average of —6 per cent. The overweights, on the other hand, with an average heat production of 9.0 calories per centimeter had a corresponding deviation of +7 per cent (See Table 5). Blunt (1926) has called attention to the fact that the underweight girl tends to have a low metabolism on the basis of calories per centimeter whereas overweights tend to have high calories per centimeter.

## HEAT PRODUCTION AS REFERRED TO SURFACE AREA

Surface area was determined from height and weight by use of tables derived from the Du Bois chart.

On the basis of surface area there was a larger difference in size between the 14-year-olds and the 18-year-olds than when height was used as the method of comparison, and a smaller difference than when weight was used. The differences computed according to height, weight, and surface area were 4, 19, and 10 per cent, respectively.

TABLE 9.—Average Heat Production per Square Meter per Hour*

| Age in years | Blunt | MacLeod | Benedict's Girl Scouts | This Study |
|---|---|---|---|---|
| 10 | 44.2 | ........ | ........ | ........ |
| 11 | 41.5 | 37.5 | ........ | ........ |
| 12 | 42.3 | 41.3 | ........ | ........ |
| 13 | 41.0 | 41.0 | ........ | ........ |
| 14 | ........ | 36.6 | 36.4 | 37.7 |
| 15 | ........ | ........ | 34.5 | 37.4 |
| 16 | ........ | ........ | 31.0 | 36.1 |
| 17 | ........ | ........ | 32.3 | 36.6 |
| 18 | ........ | ........ | 32.2 | 34.8 |

*Based on four studies.

On the basis of surface area, heat production decreased with increasing age (See Table 3). The 18-year-olds produced 34.8 calories per square meter per hour as compared to 37.7 calories produced by the 14-year-olds. This same general tendency is also shown by the results of Blunt's and Mac Leod's studies as well as by Benedict's Girl Scouts (Table 9).

Sandiford and Harrington (1925) also reported that the decrease in calories per square meter progresses very regularly with age.

In Table 10, age has been disregarded, and the heat production has been computed on the basis of surface area. When the total daily heat production was referred to surface area there was a decided difference between the total calorie production of the smaller and of the larger girls. The seven smallest girls (1.3 to 1.4 square meters) produced an average of 1220 calories as compared to an average of 1614 calories produced by the 4 largest girls (1.8 to 1.9 square meters), a difference of 32 per cent.

TABLE 10.—Average Heat Production per 24 Hours Referred to Surface Area

| Surface area in sq. m. | No. of cases | Av. total calories | Av. cal. per kg. | Av. cal. per cm. | Av. cal. per sq. m. |
|---|---|---|---|---|---|
| 1.30-1.40 | 7 | 1220 | 28.9 | 8.0 | 37.9 |
| 1.40-1.50 | 17 | 1311 | 27.6 | 8.3 | 37.5 |
| 1.50-1.60 | 34 | 1330 | 24.9 | 8.2 | 35.7 |
| 1.60-1.70 | 24 | 1418 | 24.4 | 8.6 | 36.2 |
| 1.70-1.80 | 5 | 1522 | 23.4 | 9.1 | 36.6 |
| 1.80-1.90 | 4 | 1614 | 21.9 | 9.4 | 36.2 |

Calories per centimeter also increased with increase in surface area, the smaller girls producing 8.0 calories per centimeter as compared to 9.4 calories per centimeter for the larger girls.

Heat production per kilogram decreased as surface area increased, the smaller girls averaging 28.9 calories per kilogram and the larger girls 21.9 calories per kilogram, a decrease of 32 per cent.

Calories per square meter decreased somewhat as the surface area increased. The smaller girls (1.3 to 1.4 square meters) produced 37.9 calories per square meter per hour as compared to 36.2 calories per square meter per hour for the larger girls (1.8 to 1.9 square meters), a difference of only 4.7 per cent.

## THE EFFECT OF UNDERWEIGHT AND OVERWEIGHT ON HEAT PRODUCTION PER SQUARE METER

The average heat production of the entire group of 91, the group of normals, the underweights, and the overweights, was remarkably uniform when expressed as calories per square meter. The underweights were producing a very little more and the overweights a very little less heat per square meter than the entire group and than the normals (See Table 5).

It is interesting to compare the average deviations of the overweights and the underweights from the average of the entire group by the different methods of comparison. For the overweights, on the basis of total calories, the average deviation is +8 per cent; on the basis of weight, —9 per cent; on the basis of height, +7 per cent; and, on the basis of surface area, —0.5 per cent. For the underweights the corresponding average percentage deviations are —8 per cent, +12 per cent, —6 per cent, and +2 per cent. Surface area obviously offers a better criterion for predicting the heat production of young girls whose weight deviates from the normal.

Lusk (1928) states that "per square meter of surface there is little difference in the heat production of thin women and their obese companions." Harris and Benedict say, 1919, "The number of calories produced by individuals varies greatly. When reduced to a standard of calories per square meter of body surface, the heat production varies much less widely than when the original measurements are left entirely uncorrected for the size of the individual experimented with."

## STATISTICAL TREATMENT

Tables 11 to 14 show the results of a statistical treatment of the heat production as computed by the different methods. Examination of these tables shows that the coefficient of variability decreases in the following order when the entire group is considered; calories per kilogram, total calories, calories per centimeter, and calories per square meter. Surface area would seem to be a better basis for predicting basal metabolism than either height or weight.

**TABLE 11.—Results of Study in Total Calories per 24 Hours—Treated Statistically**

| Age | Mean | Standard deviation | Coefficient of variability | Probable error of mean | Probable error of mean |
|---|---|---|---|---|---|
| *Yr.* | | | *Per cent* | | *Per cent* |
| 14 | 1340 | ±138 | 10.30 | 35.18 | 2.63 |
| 15 | 1388 | ±105 | 7.56 | 17.18 | 1.24 |
| 16 | 1326 | ±105 | 7.92 | 15.84 | 1.19 |
| 17 | 1381 | ±116 | 8.40 | 13.83 | 1.00 |
| 18 | 1365 | ±159 | 11.65 | 27.69 | 2.03 |
| Entire group | 1364 | ±124 | 9.09 | 8.77 | 0.64 |

**TABLE 12.—Results of Study in Calories per Kilogram per 24 Hours—Treated Statistically**

| Age | Mean | Standard deviation | Coefficient of variability | Probable error of mean | Probable error of mean |
|---|---|---|---|---|---|
| *Yr.* | | | *Per cent* | | *Per cent* |
| 14 | 27.3 | ±2.10 | 7.69 | 0.54 | 1.98 |
| 15 | 26.6 | ±2.24 | 8.41 | 0.36 | 1.35 |
| 16 | 25.2 | ±2.74 | 10.86 | 0.41 | 1.63 |
| 17 | 25.3 | ±2.32 | 9.16 | 0.28 | 1.10 |
| 18 | 23.4 | ±1.98 | 8.46 | 0.40 | 1.71 |
| Entire group | 25.4 | ±2.59 | 10.20 | 0.27 | 1.06 |

**TABLE 13.—Results of Study in Calories per Centimeter per 24 Hours—Treated Statistically**

| Age | Mean | Standard deviation | Coefficient of variability | Probable error of mean | Probable error of mean |
|---|---|---|---|---|---|
| *Yr.* | | | *Per cent* | | *Per cent* |
| 14 | 8.4 | ±0.62 | 7.34 | 0.16 | 1.89 |
| 15 | 8.6 | ±0.52 | 6.08 | 0.09 | 1.05 |
| 16 | 8.3 | ±0.66 | 7.94 | 0.10 | 1.20 |
| 17 | 8.5 | ±0.61 | 7.15 | 0.07 | 0.82 |
| 18 | 8.3 | ±0.84 | 10.10 | 0.15 | 1.80 |
| Entire group | 8.4 | ±0.66 | 7.82 | 0.05 | 0.59 |

**TABLE 14.—Results of Study in Calories per Square Meter per Hour—Treated Statistically**

| Age | Mean | Standard deviation | Coefficient of variability | Probable error of mean | Probable error of mean |
|---|---|---|---|---|---|
| *Yr.* | | | *Per cent* | | *Per cent* |
| 14 | 37.7 | ±2.22 | 5.89 | 0.57 | 1.51 |
| 15 | 37.4 | ±1.99 | 5.32 | 0.32 | 0.86 |
| 16 | 36.0 | ±2.88 | 8.00 | 0.43 | 1.19 |
| 17 | 36.6 | ±2.08 | 5.68 | 0.25 | 0.68 |
| 18 | 34.8 | ±2.37 | 6.81 | 0.42 | 1.21 |
| Entire group | 36.4 | ±2.48 | 6.81 | 0.18 | 0.49 |

The fact that for each age group, except one, this statistical constant is less than it is for the entire group would indicate also that age and surface area are better bases for predicting basal metabolism of girls from 14 to 18 years of age than surface area alone.

## THE VARIABILITY OF BASAL METABOLISM

Much interest is attached to the question of the constancy of the basal metabolism of an individual. It has been generally assumed that the basal metabolism of a normal individual varies little from day to day. Nevertheless, there is much evidence to show that the basal heat production of an individual does vary from day to day, and that a test made on any one day is not an invariable indication of the basal metabolic rate.

With 35 subjects from 17 to 43 years of age, Benedict (1915) found a variation in oxygen consumption above the minimum to range from 3.5 to 31.3 per cent, with an average of 13.9 per cent, and states that "these results show clearly the error of assuming, as is frequently done in metabolism experiments, a basal value for any one individual to compare with metabolism measurements made with a superimposed factor."

Blunt and Dye (1921) report consecutive daily observations on 17 women with a maximum of 26 observations on one of the number. With these women the range in heat production from day to day was also quite marked and also varied greatly with the individual. One woman produced 28.8 per cent more heat on the day of greatest heat production than on the day of lowest heat production; another woman had a maximum variation of only 7.4 per cent. The average variation of 13.2 per cent differed little from Benedict's average.

Kunde (1923) reports daily observations on herself during a year's time with marked variations in heat production.

Hafkesbring and Collett (1924) report heat production figures for one subject for 96 almost consecutive days and for another subject for 80 almost consecutive days. For one of these women the difference between highest and lowest figures was 277 calories or 24.6 per cent, and for the other 368 calories or 35.3 per cent.

Benedict (1928) reports observations on a woman for a period of years with a varying number of observations during each year. The greatest variation in heat production for this subject during any one year was 253 calories, or 21 per cent; while her smallest deviation was 69 calories, or 5.6 per cent. Even with this well trained subject the variation was noteworthy.

Benedict and Gustafson (1928) report results of observations made once each month for a varying length of time on a group of 20 young college women in Wellesley. With these young women the range in heat production in successive months varied considerably, the smallest variation being 97 calories, or 8 per cent, the largest 479 calories, or 44 per cent, during a year's time. Only two of this group of 20 showed a variation of highest from lowest heat production of less than 10 per cent.

Griffith et al. (1929) give the results of continuous observation of three women for a year's period of time. Two of these women were laboratory technicians while the third was a junior medical student. These authors state "evidently the metabolism is inherently variable". These workers found much less variability from day to day, however, than has been reported in other studies. They consider a deviation of 10 per cent during a year's time an "exceptional extreme variation".

To contribute to the study of basal metabolism of young women which was being made at the Ohio State University, five students of the School of Home Economics volunteered as subjects for observation of day by day variations in basal metabolism.

The apparatus and method used were as have been described earlier in this report. For these five young women, results of 47 observations are recorded for one, 42 for another, 27 for a third, 25 for a fourth, and 23 for the fifth. Table 2 (Appendix) gives the fundamental data for these observations.

Comparison of the actual heat production figures with the predicted values according to the Harris-Benedict standard shows an average deviation of —3.6, —4.4, —8.5, —6.9, and +1.8 per cent, respectively.

When comparison was made with the predicted values according to the Aub-DuBois standard the corresponding average deviations were —6.4, —5.1, —7.5, —8.0, and —1.0 per cent.

**TABLE 15.—Extreme Variation in Daily Heat Production**

| Subject | Age | Total days observed | Heat production per day | | | Variation of maximum above minimum | | Extreme variation from average | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Maximum | Minimum | Average | | | | |
| *No.* | *Yr.* | *No.* | *Calories* | *Calories* | *Calories* | *Calories* | *Per cent* | *Calories* | *Per cent* |
| 1........... | 22 | 47 | 1508 | 1171 | 1324 | 337 | 28.8 | 184 | 13.9 |
| 2........... | 25 | 25 | 1363 | 1181 | 1261 | 182 | 15.4 | 102 | 8.1 |
| 3........... | 22 | 27 | 1331 | 1104 | 1178 | 227 | 20.6 | 153 | 13.0 |
| 4........... | 21 | 23 | 1507 | 1185 | 1349 | 322 | 27.2 | 164 | 12.2 |
| 5........... | 21 | 42 | 1441 | 1270 | 1350 | 171 | 13.5 | 91 | 6.7 |

In Table 15 are given average figures as well as the maximum and the minimum for each subject with the total variation and the percentage deviation of the maximum from the minimum. As shown by this table the range for all five subjects is large. The greatest range is 337 calories, or 28.8 per cent, with the smallest range 171 calories, or 13 per cent.

However, when the deviations above and below the average of each subject are taken, the variations do not appear as great (See Table 16). The averages of total variations from the average on the basis of surface area are all less than 4 per cent.

**TABLE 16.—Deviations in Heat Production from the Average**

| Subject | Age | Observations | Av. cal. per sq. m. | Maximum above average | | Maximum below average | | Av. of individual positive variations from average | Av. of individual negative variations from average | Av. of total variations from average |
|---|---|---|---|---|---|---|---|---|---|---|
| *No.* | *Yr.* | *No.* | *Per hr.* | *Calories* | *Per cent* | *Calories* | *Per cent* | *Per cent* | *Per cent* | *Per cent* |
| 1...... | 22 | 47 | 34.6 | 4.66 | 13.47 | 4.11 | 11.88 | 3.85 | 2.63 | 3.12 |
| 2....... | 24 | 25 | 35.1 | 2.78 | 7.92 | 2.29 | 6.53 | 2.39 | 2.21 | 2.29 |
| 3....... | 22 | 27 | 34.2 | 4.29 | 12.54 | 2.28 | 6.66 | 3.52 | 3.09 | 3.29 |
| 4....... | 21 | 23 | 34.0 | 4.04 | 11.88 | 4.28 | 12.58 | 3.23 | 4.22 | 3.66 |
| 5....... | 21 | 42 | 36.7 | 2.31 | 6.30 | 2.33 | 6.35 | 2.60 | 2.04 | 2.23 |

The greatest variation is found in Subject 1 for whom an extremely high value was recorded for December 21. Although this young woman had been observed frequently enough to be considered a trained subject, and although all the conditions seemed to be as usual, the high value suggests that her condition may not have been basal.

Benedict (1928) has noted correspondingly high heat production figures for Wellesley students just before the Christmas holidays and attributes the high value to excitement. For Subject V, whose variation is almost as high as Subject I, the extreme high value was observed February 24. What Benedict terms "the varying stimuli occurring in any student's year at college" are probably real factors to be considered in connection with the basal metabolism of young college women.

For each subject the heat production per day during menstrual periods has been averaged and compared with a corresponding average for intermenstrual periods. With four of the young women the average calorie production during menstrual periods was but slightly less than that produced during intermenstrual periods. For one subject the corresponding value was slightly higher. With the small number of subjects and the few menstrual periods included it seems unjustifiable to attempt to draw any conclusions concerning the influence of menstruation upon basal metabolism. If any conclusion were justifiable it would seem to indicate a tendency toward a lowered basal metabolic rate during menstruation.

### SEASONAL VARIATIONS IN BASAL METABOLISM

The possible influence of season upon the basal metabolism has received considerable attention recently. Results of studies seem somewhat contradictory. Benedict and Gustafson (1928) report the results of a study made at Wellesley College which continued 15 months for five subjects and 13 months for eight subjects. No observations were made during July, August, and September. The authors state that "the varying stimuli incidental to college life undoubtedly affected the individual monthly measurements but the average values for the oxygen consumption strongly suggest that the metabolism tends to be at a low level in the winter and to rise to a higher level during the spring and summer."

Griffith et al. (1928) as a result of continuous observations of two men for two years and three women for one year found that seasonal changes were evident, but that such changes varied with the subjects. With four of their subjects the lowest heat production figures were found in the late summer and early fall. With one of the four there was a marked depression in the spring also. With the fifth subject the spring depression was much more decided.

Hitchcock and Wardwell (1929), working with two subjects for more than a year and with two others during the winter and spring, conclude that "there seems to be a seasonal variation with the lowest metabolic rate occurring in the winter or spring and the highest in the summer or autumn. The time of year at which the metabolic rate begins to increase seems to depend to some extent upon the personal habits of the subject."

In the light of the observations just referred to it seemed worth while to consider season in relation to the basal metabolism figures obtained for the 96 young women observed at the Ohio State University.

Although the larger group of the Ohio girls were younger than the Wellesley College women the conditions of living seemed to be similar. The observations of the two groups extended over corresponding periods of the year, namely, from October to June. It seemed worth while, therefore, to consider the values for basal metabolism obtained in reference to the time of year during which the observations were made.

Since the group was not a composite one throughout the year, as was the case with Benedict's subjects, it seemed unjustifiable to base any conclusions upon average total oxygen consumption. The average heat production per kilogram and per square meter was therefore computed for each month and used for the conparison. Table 17 shows the result of the computation.

**TABLE 17.—Average Heat Production of 96 Girls—Referred to Month During Which the Observations Were Made**

| Month | Number of observations | Calories per kilogram | Calories per sq. m. per hr. |
|---|---|---|---|
| October | 19 | 25.0 | 35.8 |
| November | 80 | 25.1 | 35.5 |
| December | 57 | 24.6 | 35.6 |
| January | 51 | 24.8 | 35.5 |
| February | 58 | 24.6 | 35.9 |
| March | 25 | 23.6 | 35.2 |
| April | 60 | 25.3 | 36.3 |
| May | 43 | 25.5 | 36.4 |
| June | 9 | 25.7 | 36.5 |

When averages were made for the three seasons it was found that the average energy production, whether based on calories per kilogram or upon surface area, was somewhat greater during April, May, and June, the spring quarter, than during either the autumn quarter, October, November and December, or the winter quarter, January, February, and March. The differences are slight but noticeable (See Table 18).

**TABLE 18.—Average Heat Production of 96 Girls—Referred to Season**

| Season | Number of observations | Calories per kilogram | Calories per square meter per hour |
|---|---|---|---|
| Autumn (Oct., Nov., Dec.) | 156 | 24.9 | 35.6 |
| Winter (Jan., Feb., Mar.) | 134 | 24.5 | 35.6 |
| Spring (April, May, June) | 112 | 25.4 | 36.3 |

If the comparison of the heat production of this group of girls from month to month on the basis of surface area and of weight is justifiable, then there is evidence to show that at least there is a tendency toward an increased metabolism during the warmer weather.

## SUMMARY

Results of 236 observations of the basal metabolism of 91 young women from 14 to 18 years of age, inclusive, and of 164 observations made on five young women from 21 to 24 years of age are reported. Oxygen consumption per minute was measured by means of a Benedict-Roth Portable Respiration Apparatus and the basal metabolism computed from the oxygen consumption figures.

**I. Results of observations of 91 girls from 14 to 18 years old.**

A. Enough figures have been obtained for the 15-, 16-, 17-, and 18-year-olds to justify conclusions for these ages. The figures for the small group of 14-year-olds are in accord with figures obtained by other workers for that age group and may be considered as corroborative.

B. Average oxygen consumption per minute according to age was as follows: seven 14-year-olds, 193 cubic centimeters; seventeen 15-year-olds, 200 cubic centimeters; twenty 16-year-olds, 192 cubic centimeters; thirty-two 17-year-olds, 199 cubic centimeters; fifteen 18-year-olds, 197 cubic centimeters. Average oxygen consumption for the entire group was 197 cubic centimeters per minute.

C. Average basal heat production per 24 hours (computed) was as follows: 1340 calories for 14 years, 1388 for 15 years, 1326 for 16 years, 1381 for 17 years, and 1365 for 18 years. The average for each age differs little from the average for the entire group, namely, 1364 calories. No regularity of increase or decrease per 24 hours occurred with increased age. The average heat production of the overweights as a group was 8 per cent above and of the underweights was 7.5 below the average of the group.

D. Average basal calorie production per kilogram per 24 hours for each age group was as follows: fourteen years, 27.3; fifteen years, 26.6; sixteen years, 25.2; seventeen years, 25.3; and eighteen years, 23.4. The average for the entire group regardless of age was 25.4 calories per kilogram.

Heat production per kilogram decreased fairly regularly as age increased.

When age was disregarded heat production per kilogram decreased quite decidedly with increased weight. The overweights as a group average 9 per cent less and the underweights 12 per cent more per kilogram than the entire group.

E. Average calories per centimeter per 24 hours were remarkably uniform for each age group as follows: fourteen years, 8.4; fifteen years, 8.6; sixteen years, 8.3; seventeen years, 8.5; and eighteen years, 8.3. The average for the entire group regardless of age was 8.4 calories per centimeter.

Overweights varied from the group average by +7 per cent and underweights by —6 per cent.

F. Average calories per square meter per hour decreased in a fairly regular manner with age as follows: fourteen years, 37.7 calories; fifteen years, 37.4 calories; sixteen years, 36.0 calories; seventeen years, 36.6 calories; and eighteen years, 34.8 calories. The average for the entire group was 36.4.

Average calorie production of overweights was only 0.5 per cent below and average calorie production of underweights only 2 per cent above the average of the entire group when compared on the basis of heat production per square meter per hour.

G. Average heat production figures for each age group were higher than corresponding values found for Benedict's Girl Scouts.

The fact that the Benedict standards are based on observations made when the subjects were sound asleep probably accounts for the fact that these figures are lower than figures obtained in this study where the girls were awake at the time of observation.

H. Average heat production figures for each age group were found to be lower than the Aub-DuBois standards.

I. Comparison of statistical constants obtained with each of four methods of comparing basal metabolism figures would seem to indicate that predictions of basal metabolism on surfact area and age are less liable to error than those based on height or weight.

**II. Results of observations concerning the variability of basal metabolism.**

A. Forty-seven observations were made of the basal metabolism of one young woman; forty-two of a second; twenty-seven for a third; twenty-five for a fourth; and twenty-three for a fifth.

B. Day by day variations were quite marked, the maximum variation above the minimum being 14, 15, 21, 27, and 29 per cent, respectively, for the five young women. These variations compare favorably with corresponding variations as shown in other studies.

Extreme variations from the average were somewhat less, being 7, 8, 12, 13, and 14 per cent, respectively.

The average of total variations from the average were only 2, 2, 3, and 4 per cent, respectively, as based on surface area.

When compared with the Harris-Benedict standard, the average of the deviations of the observed from the predicted were —1.8, —3.6, —4.4, —6.9, and —8.5 per cent.

When comparison was made with the Aub-DuBois Standard, the averages of the deviations of the observed from the predicted were —1.0, —5.1, —6.4, —7.5, and —8.0 per cent.

**III. Seasonal variation in basal metabolism.**

Figures of basal metabolism obtained from observations of the 91 young girls and the 5 young women were arranged according to the month during which the observations were made and averages computed for each month. Averages were then made according to the season. Although the differences were small there was an increased calorie production during the spring (April, May, June) as compared to heat production during the autumn and winter.

## CONCLUSIONS

Standards for prediction of basal metabolism of young girls from 14 to 18 years should be somewhat higher than those of Benedict which are based on his Girl Scout data and somewhat lower than the Aub-DuBois standards.

Age and surface area afford a better method of prediction of basal metabolism than either height or weight.

For young college women the daily fluctuation in basal metabolism is noticeable.

Basal metabolism of young college women tends to be somewhat higher in the spring than in the autumn or winter.

## APPENDIX

### TABLE 1.—Fundamental Data

| Subject No. | Observation | Age | | Weight | Height | Surface area | Pulse rate | Average oxygen per minute | Calories | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Per 24 hr. | Per kilo per 24 hr. | Per cm. per 24 hr. | Per sq. m. per hr. |
| | *No.* | *Yr.* | *Mo.* | *Kg.* | *Cm.* | *Sq. M.* | | *cc.* | | | | |
| 1 | 2 | 14 | 3 | 46.2 | 155 | 1.42 | 66 | 169 | 1174 | 25.4 | 7.6 | 34.4 |
| 2 | 2 | 13 | 9 | 56.4 | 167 | 1.63 | 70 | 218 | 1516 | 26.9 | 9.1 | 38.8 |
| 3 | 3 | 13 | 8 | 51.2 | 162 | 1.53 | 74 | 218 | 1512 | 29.5 | 9.3 | 41.2 |
| 4 | 3 | 14 | 5 | 52.2 | 161 | 1.53 | 77 | 186 | 1294 | 24.8 | 8.0 | 35.2 |
| 5 | 3 | 14 | 3 | 54.8 | 161 | 1.57 | 55 | 208 | 1448 | 26.4 | 9.0 | 38.4 |
| 6 | 3 | 14 | 4 | 39.8 | 153 | 1.32 | 72 | 179 | 1243 | 31.2 | 8.1 | 39.2 |
| 7 | 2 | 14 | 1 | 44.2 | 149 | 1.35 | 60 | 172 | 1190 | 26.9 | 8.0 | 36.7 |
| Average of seven 14-year-old girls | | | | | | | | | 1340 | 27.3 | 8.4 | 37.7 |
| 8 | 2 | 14 | 11 | 46.7 | 159 | 1.46 | 69 | 180 | 1249 | 26.7 | 7.9 | 35.6 |
| 9 | 3 | 15 | 0 | 57.0 | 165 | 1.62 | 78 | 215 | 1495 | 26.2 | 9.1 | 38.4 |
| 10 | 3 | 15 | 3 | 46.0 | 162 | 1.46 | 78 | 208 | 1446 | 31.4 | 8.9 | 41.3 |
| 11 | 2 | 14 | 6 | 47.3 | 158 | 1.45 | 67 | 206 | 1426 | 30.1 | 9.0 | 41.0 |
| 12 | 3 | 14 | 7 | 58.3 | 162 | 1.61 | 70 | 203 | 1408 | 24.2 | 8.7 | 36.4 |
| 13 | 2 | 15 | 4 | 70.0 | 172 | 1.83 | 71 | 231 | 1604 | 23.2 | 9.3 | 36.5 |
| 14 | 2 | 14 | 7 | 56.1 | 164 | 1.60 | 69 | 204 | 1414 | 25.2 | 8.6 | 36.8 |
| 15 | 2 | 14 | 8 | 48.8 | 156 | 1.46 | 72 | 192 | 1330 | 27.3 | 8.5 | 38.0 |
| 16 | 2 | 14 | 10 | 59.0 | 166 | 1.66 | 73 | 217 | 1510 | 25.6 | 9.1 | 37.9 |
| 17 | 2 | 15 | 3 | 43.2 | 157 | 1.39 | 61 | 162 | 1119 | 25.9 | 7.1 | 33.6 |
| 18 | 3 | 15 | 5 | 52.3 | 162 | 1.54 | 64 | 193 | 1340 | 25.6 | 8.3 | 36.2 |
| 19 | 3 | 15 | 1 | 54.5 | 160 | 1.55 | 66 | 195 | 1352 | 24.8 | 8.4 | 36.4 |
| 20 | 3 | 15 | 2 | 56.3 | 162 | 1.59 | 64 | 196 | 1365 | 24.2 | 8.4 | 35.8 |
| 21 | 3 | 14 | 10 | 48.4 | 166 | 1.52 | 66 | 197 | 1369 | 28.3 | 8.2 | 37.5 |
| 22 | 3 | 14 | 7 | 53.5 | 164 | 1.58 | 67 | 199 | 1381 | 25.8 | 8.4 | 36.4 |
| 23 | 2 | 15 | 2 | 48.1 | 162 | 1.49 | 72 | 210 | 1458 | 30.3 | 9.0 | 40.8 |
| 24 | 3 | 15 | 4 | 47.7 | 160 | 1.48 | 65 | 191 | 1325 | 27.8 | 8.3 | 37.3 |
| Average of seventeen 15-year-old girls | | | | | | | | | 1388 | 26.6 | 8.6 | 37.4 |
| 25 | 2 | 16 | 2 | 54.0 | 160 | 1.55 | 72 | 188 | 1300 | 24.1 | 8.1 | 34.9 |
| 26 | 3 | 15 | 7 | 55.8 | 164 | 1.60 | 63 | 181 | 1261 | 22.6 | 7.7 | 32.8 |
| 27 | 2 | 16 | 3 | 55.0 | 156 | 1.54 | 71 | 197 | 1366 | 24.8 | 8.8 | 37.0 |
| 28 | 3 | 15 | 9 | 57.4 | 158 | 1.57 | 74 | 197 | 1370 | 23.9 | 8.7 | 36.4 |
| 29 | 3 | 16 | 4 | 51.0 | 166 | 1.56 | 69 | 190 | 1323 | 25.9 | 8.0 | 35.3 |
| 30 | 3 | 16 | 1 | 54.8 | 160 | 1.56 | 59 | 205 | 1426 | 26.0 | 8.9 | 38.1 |
| 31 | 2 | 15 | 7 | 50.3 | 163 | 1.52 | 81 | 217 | 1502 | 29.9 | 9.2 | 41.2 |
| 32 | 2 | 15 | 8 | 41.4 | 149 | 1.31 | 66 | 175 | 1213 | 29.3 | 8.1 | 38.6 |
| 33 | 3 | 16 | 1 | 60.8 | 162 | 1.65 | 54 | 242 | 1591 | 26.2 | 9.8 | 40.2 |
| 34 | 3 | 16 | 1 | 52.8 | 162 | 1.55 | 62 | 163 | 1133 | 21.4 | 7.0 | 30.4 |
| 35 | 3 | 16 | 4 | 57.0 | 158 | 1.57 | 61 | 175 | 1218 | 21.4 | 7.7 | 32.3 |
| 36 | 3 | 15 | 6 | 53.5 | 162 | 1.57 | 71 | 181 | 1255 | 23.5 | 7.8 | 33.3 |
| 37 | 3 | 15 | 7 | 60.3 | 162 | 1.64 | 63 | 198 | 1377 | 22.8 | 8.5 | 35.0 |
| 38 | 2 | 16 | 0 | 45.7 | 152 | 1.40 | 69 | 178 | 1233 | 27.0 | 8.1 | 36.7 |
| 39 | 2 | 16 | 0 | 52.3 | 168 | 1.58 | 72 | 192 | 1335 | 25.5 | 7.9 | 35.2 |
| 40 | 3 | 16 | 2 | 43.3 | 158 | 1.40 | 64 | 175 | 1218 | 28.1 | 7.7 | 36.2 |
| 41 | 2 | 16 | 4 | 58.3 | 157 | 1.58 | 66 | 206 | 1431 | 24.5 | 9.1 | 37.7 |
| 42 | 2 | 16 | 4 | 43.4 | 151 | 1.35 | 70 | 194 | 1348 | 31.1 | 8.9 | 41.6 |
| 43 | 2 | 16 | 2 | 52.6 | 172 | 1.62 | 64 | 190 | 1323 | 25.2 | 7.7 | 34.0 |
| 44 | 2 | 16 | 3 | 60.6 | 154 | 1.59 | 70 | 186 | 1297 | 21.4 | 8.4 | 34.0 |
| Average of twenty 16-year-old girls | | | | | | | | | 1326 | 25.2 | 8.3 | 36.0 |

TABLE 1.—Fundamental Data—Continued

| Subject No. | Observation | Age | | Weight | Height | Surface area | Pulse rate | Average oxygen per minute | Calories | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Per 24 hr. | Per kilo per 24 hr. | Per cm. per 24 hr. | Per sq. m. per hr. |
| | *No.* | *Yr.* | *Mo.* | *Kg.* | *Cm.* | *Sq. M.* | | *cc.* | | | | |
| 45 | 3 | 16 | 8 | 49.6 | 163 | 1.52 | 74 | 198 | 1373 | 27.7 | 8.4 | 37.6 |
| 46 | 3 | 17 | 0 | 66.6 | 167 | 1.75 | 65 | 196 | 1358 | 20.4 | 8.1 | 32.3 |
| 47 | 2 | 17 | 3 | 42.2 | 155 | 1.36 | 63 | 175 | 1214 | 28.8 | 7.8 | 37.2 |
| 48 | 3 | 17 | 3 | 43.8 | 161 | 1.44 | 67 | 175 | 1217 | 27.2 | 7.6 | 35.3 |
| 49 | 3 | 17 | 5 | 41.3 | 150 | 1.32 | 79 | 175 | 1212 | 29.3 | 8.1 | 38.2 |
| 50 | 3 | 16 | 10 | 56.1 | 166 | 1.62 | 80 | 217 | 1504 | 26.8 | 9.1 | 38.7 |
| 51 | 3 | 16 | 10 | 53.2 | 154 | 1.50 | 70 | 185 | 1286 | 24.2 | 8.4 | 35.7 |
| 52 | 3 | 17 | 3 | 49.7 | 156 | 1.47 | 72 | 181 | 1258 | 25.3 | 8.1 | 35.7 |
| 53 | 3 | 17 | 4 | 51.7 | 157 | 1.51 | 75 | 193 | 1340 | 25.9 | 8.5 | 37.0 |
| 54 | 3 | 17 | 5 | 55.9 | 163 | 1.60 | 64 | 195 | 1358 | 24.3 | 8.3 | 35.4 |
| 55 | 2 | 17 | 0 | 60.3 | 167 | 1.67 | 65 | 208 | 1445 | 24.0 | 8.6 | 36.0 |
| 56 | 2 | 17 | 4 | 61.2 | 170 | 1.71 | 59 | 218 | 1520 | 24.8 | 8.9 | 37.0 |
| 57 | 3 | 16 | 11 | 58.1 | 165 | 1.64 | 68 | 204 | 1418 | 24.4 | 8.6 | 36.0 |
| 58 | 2 | 17 | 5 | 48.3 | 153 | 1.43 | 64 | 193 | 1343 | 27.8 | 8.8 | 39.1 |
| 59 | 2 | 17 | 6 | 55.4 | 160 | 1.56 | 70 | 196 | 1365 | 24.6 | 8.5 | 36.4 |
| 60 | 2 | 17 | 6 | 51.5 | 157 | 1.49 | 56 | 206 | 1435 | 27.9 | 9.1 | 40.1 |
| 61 | 2 | 16 | 10 | 53.7 | 165 | 1.59 | 78 | 220 | 1527 | 28.4 | 9.2 | 40.0 |
| 62 | 3 | 17 | 3 | 47.6 | 156 | 1.45 | 66 | 195 | 1358 | 28.5 | 8.7 | 39.0 |
| 63 | 3 | 17 | 4 | 51.7 | 161 | 1.53 | 61 | 171 | 1191 | 23.0 | 7.4 | 32.4 |
| 64 | 3 | 17 | 6 | 73.9 | 170 | 1.85 | 73 | 240 | 1668 | 22.6 | 9.8 | 37.6 |
| 65 | 2 | 17 | 5 | 48.1 | 160 | 1.48 | 81 | 190 | 1325 | 27.6 | 8.3 | 37.3 |
| 66 | 3 | 17 | 5 | 53.0 | 168 | 1.60 | 72 | 215 | 1492 | 28.2 | 8.9 | 38.8 |
| 67 | 3 | 17 | 6 | 62.4 | 162 | 1.66 | 69 | 209 | 1449 | 23.2 | 8.9 | 36.4 |
| 68 | 3 | 17 | 5 | 52.2 | 162 | 1.54 | 79 | 195 | 1352 | 25.9 | 8.4 | 36.6 |
| 69 | 2 | 17 | 1 | 64.1 | 159 | 1.66 | 72 | 200 | 1395 | 21.8 | 8.8 | 35.0 |
| 70 | 3 | 17 | 5 | 52.6 | 161 | 1.55 | 77 | 196 | 1363 | 25.9 | 8.5 | 36.6 |
| 71 | 3 | 17 | 6 | 56.5 | 174 | 1.67 | 79 | 213 | 1479 | 26.2 | 8.5 | 36.9 |
| 72 | 3 | 17 | 2 | 62.1 | 164 | 1.68 | 71 | 221 | 1533 | 24.7 | 9.4 | 38.0 |
| 73 | 2 | 17 | 6 | 54.0 | 162 | 1.57 | 59 | 168 | 1171 | 21.7 | 7.2 | 31.1 |
| 74 | 3 | 17 | 4 | 58.9 | 162 | 1.63 | 63 | 192 | 1334 | 22.7 | 8.2 | 34.1 |
| 75 | 2 | 17 | 1 | 64.4 | 165 | 1.71 | 62 | 222 | 1544 | 24.0 | 9.4 | 37.6 |
| 76 | 2 | 16 | 11 | 58.3 | 164 | 1.63 | 70 | 196 | 1359 | 23.3 | 8.3 | 34.8 |
| Average of thirty-two 17-year-old girls | | | | | | | | | 1381 | 25.3 | 8.5 | 36.6 |
| 77 | 3 | 17 | 10 | 55.3 | 166 | 1.61 | 55 | 195 | 1356 | 24.5 | 8.2 | 35.1 |
| 78 | 3 | 17 | 11 | 61.0 | 166 | 1.68 | 70 | 196 | 1353 | 22.2 | 8.2 | 33.6 |
| 79 | 3 | 17 | 8 | 48.6 | 160 | 1.49 | 71 | 180 | 1249 | 25.7 | 7.8 | 34.9 |
| 80 | 3 | 17 | 7 | 54.4 | 160 | 1.55 | 73 | 173 | 1203 | 22.1 | 7.5 | 32.3 |
| 81 | 2 | 18 | 1 | 64.4 | 168 | 1.73 | 67 | 243 | 1687 | 26.2 | 10.0 | 40.6 |
| 82 | 3 | 17 | 8 | 68.9 | 163 | 1.75 | 64 | 216 | 1499 | 21.7 | 9.2 | 35.7 |
| 83 | 2 | 17 | 8 | 58.6 | 164 | 1.64 | 57 | 184 | 1278 | 21.6 | 7.8 | 32.5 |
| 84 | 3 | 18 | 1 | 58.5 | 159 | 1.60 | 73 | 201 | 1395 | 23.8 | 8.8 | 36.3 |
| 85 | 3 | 17 | 7 | 53.5 | 163 | 1.57 | 72 | 193 | 1342 | 25.0 | 8.2 | 35.6 |
| 86 | 3 | 17 | 11 | 50.8 | 161 | 1.52 | 57 | 156 | 1086 | 21.3 | 6.7 | 29.8 |
| 87 | 3 | 17 | 8 | 53.8 | 166 | 1.59 | 63 | 181 | 1255 | 23.3 | 7.6 | 32.9 |
| 88 | 3 | 17 | 9 | 79.9 | 166 | 1.88 | 70 | 224 | 1560 | 19.5 | 9.4 | 34.6 |
| 89 | 3 | 18 | 0 | 72.1 | 175 | 1.87 | 59 | 234 | 1624 | 22.5 | 9.3 | 36.2 |
| 90 | 3 | 17 | 7 | 48.7 | 157 | 1.47 | 73 | 180 | 1248 | 25.7 | 7.9 | 35.4 |
| 91 | 3 | 18 | 0 | 51.4 | 161 | 1.52 | 75 | 192 | 1334 | 26.0 | 8.3 | 36.6 |
| Average of fifteen 18-year-old girls | | | | | | | | | 1365 | 23.4 | 8.3 | 34.8 |

TABLE 2.—Day by Day Variations in Basal Metabolism of Young Women

| Subject No. | Date of observation | Age Yr. | Age Mo. | Weight | Height | Pulse rate | Oxygen consumed | Heat production per 24 hr. | Heat production per sq. m. per hr. | Deviation of actual from predicted: Aub-Du Bois prediction | Deviation of actual from predicted: Harris-Benedict prediction |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Yr. | Mo. | Kg. | Cm. | | cc. | Cal. | Cal. | | |
| 1 | 10-25-26 | 22 | 0 | 53.3 | 167 | 76 | 195 | 1352 | 35.4 | − 4.2 | − 1.4 |
| | 10-26-26 | 22 | 0 | 53.3 | 167 | 84 | 197 | 1367 | 35.8 | − 3.1 | − 2.8 |
| | 10-27-26 | 22 | 0 | 53.3 | 167 | 74 | 194 | 1350 | 35.4 | − 4.4 | − 1.5 |
| | 10-28-26 | 22 | 0 | 53.3 | 167 | 80 | 187 | 1301 | 34.1 | − 7.8 | − 5.1 |
| | 10-29-26 | 22 | 0 | 53.3 | 167 | 79 | 178 | 1235 | 32.4 | −12.4 | − 9.9 |
| | 10-30-26 | 22 | 0 | 53.3 | 167 | 81 | 188 | 1307 | 34.2 | − 7.4 | − 4.7 |
| | 11- 2-26 | 22 | 0 | 53.3 | 167 | 78 | 195 | 1353 | 35.4 | − 4.1 | − 1.3 |
| | 11- 4-26 | 22 | 0 | 53.3 | 167 | 75 | 192 | 1331 | 34.9 | − 5.7 | − 2.9 |
| | 11- 5-26 | 22 | 0 | 53.3 | 167 | 76 | 205 | 1425 | 37.3 | + 1.0 | + 3.9 |
| | 11- 6-26 | 22 | 0 | 53.3 | 167 | 83 | 196 | 1364 | 35.7 | − 3.3 | − 5.1 |
| | 11- 8-26 | 22 | 0 | 53.3 | 167 | 78 | 189 | 1309 | 34.3 | − 7.2 | − 4.5 |
| | 11- 9-26 | 22 | 1 | 53.3 | 167 | 71 | 186 | 1290 | 33.8 | − 8.5 | − 5.9 |
| | 11-10-26 | 22 | 1 | 53.3 | 167 | 71 | 181 | 1257 | 33.0 | − 8.3 | − 5.9 |
| | 11-11-26 | 22 | 1 | 53.3 | 167 | 77 | 188 | 1303 | 34.2 | − 7.7 | − 4.9 |
| | 11-12-26 | 22 | 1 | 53.3 | 167 | 74 | 186 | 1293 | 33.9 | − 8.4 | − 5.7 |
| | 11-13-26 | 22 | 1 | 53.3 | 167 | 79 | 191 | 1327 | 34.8 | − 5.9 | − 3.2 |
| | 11-15-26 | 22 | 1 | 53.3 | 167 | 71 | 192 | 1335 | 35.0 | − 5.4 | − 2.6 |
| | 11-17-26 | 22 | 1 | 53.3 | 167 | 73 | 186 | 1293 | 33.9 | − 8.3 | − 5.7 |
| | 11-18-26 | 22 | 1 | 53.3 | 167 | 71 | 189 | 1311 | 34.4 | − 7.1 | − 4.4 |
| | 11-19-26 | 22 | 1 | 53.3 | 167 | 72 | 181 | 1258 | 33.0 | −10.8 | − 8.2 |
| | 11-22-26 | 22 | 1 | 53.3 | 167 | 71 | 189 | 1313 | 34.4 | − 6.9 | − 4.2 |
| | 11-23-26 | 22 | 1 | 53.3 | 167 | 70 | 194 | 1348 | 35.3 | − 4.4 | − 1.6 |
| | 11-24-26 | 22 | 1 | 53.3 | 167 | 73 | 190 | 1317 | 34.5 | − 6.6 | − 3.9 |
| | 11-29-26 | 22 | 1 | 53.5 | 167 | 75 | 186 | 1291 | 33.6 | − 9.1 | − 6.0 |
| | 11-30-26 | 22 | 1 | 53.5 | 167 | 74 | 186 | 1295 | 33.7 | − 8.8 | − 5.7 |
| | 12- 2-26 | 22 | 1 | 53.5 | 167 | 79 | 203 | 1413 | 36.8 | − 0.5 | + 3.0 |
| | 12- 3-26 | 22 | 1 | 53.5 | 167 | 77 | 209 | 1454 | 37.9 | + 2.3 | + 5.9 |
| | 12- 4-26 | 22 | 1 | 53.5 | 167 | 87 | 198 | 1376 | 35.8 | − 3.1 | + 0.2 |
| | 12- 6-26 | 22 | 1 | 53.5 | 167 | 74 | 192 | 1331 | 34.7 | − 6.3 | − 3.0 |
| | 12- 7-26 | 22 | 1 | 53.5 | 167 | 75 | 191 | 1324 | 34.5 | − 6.8 | − 3.6 |
| | 12- 8-26 | 22 | 1 | 53.5 | 167 | 72 | 182 | 1261 | 32.8 | −11.2 | − 8.2 |
| | 12- 9-26 | 22 | 2 | 53.5 | 167 | 69 | 184 | 1275 | 33.2 | −10.2 | − 7.1 |
| | 12-10-26 | 22 | 2 | 53.5 | 167 | 66 | 189 | 1314 | 34.2 | − 7.5 | − 4.3 |
| | 12-11-26 | 22 | 2 | 53.5 | 167 | 72 | 181 | 1258 | 32.8 | −11.4 | − 8.3 |
| | 12-13-26 | 22 | 2 | 53.5 | 167 | 67 | 191 | 1328 | 34.6 | − 6.5 | − 3.2 |
| | 12-14-26 | 22 | 2 | 53.5 | 167 | 70 | 194 | 1348 | 35.1 | − 5.1 | − 1.8 |
| | 12-15-26 | 22 | 2 | 53.5 | 167 | 75 | 187 | 1297 | 33.8 | − 8.7 | − 5.5 |
| | 12-16-26 | 22 | 2 | 53.5 | 167 | 71 | 192 | 1332 | 34.7 | − 6.2 | − 3.0 |
| | 12-21-26 | 22 | 2 | 53.5 | 167 | 65 | 217 | 1508 | 39.3 | + 6.8 | + 9.8 |
| | 1- 6-27 | 22 | 2 | 53.5 | 167 | 66 | 191 | 1324 | 34.5 | − 6.7 | − 3.5 |
| | 1- 7-27 | 22 | 2 | 53.5 | 167 | 72 | 187 | 1302 | 33.9 | − 8.3 | − 5.2 |
| | 1- 8-27 | 22 | 2 | 53.5 | 167 | 69 | 169 | 1171 | 30.5 | −17.6 | −14.7 |
| | 1-15-27 | 22 | 3 | 53.5 | 167 | 73 | 184 | 1281 | 33.4 | − 9.8 | − 6.7 |
| | 1-20-27 | 22 | 3 | 53.5 | 167 | 74 | 187 | 1299 | 33.8 | − 8.5 | − 5.4 |
| | 1-21-27 | 22 | 3 | 53.5 | 167 | 73 | 200 | 1389 | 36.2 | − 2.2 | + 1.2 |
| | 1-22-27 | 22 | 3 | 53.5 | 167 | 76 | 189 | 1311 | 34.1 | − 7.7 | − 4.5 |
| | 1-28-27 | 22 | 3 | 53.5 | 167 | 82 | 206 | 1428 | 37.2 | + 0.5 | + 4.0 |
| Average | | | | | | | 191 | 1324 | 34.6 | − 6.4 | − 3.6 |

**TABLE 2.—Day by Day Variations in Basal Metabolism of Young Women—Continued**

| Subject No. | Date of observation | Age | | Weight | Height | Pulse rate | Oxygen consumed | Heat production per 24 hr. | Heat production per sq. m. per hr. | Deviation of actual from predicted: Aub-Du Bois prediction | Deviation of actual from predicted: Harris-Benedict prediction |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *Yr.* | *Mo.* | *Kg.* | *Cm.* | | *cc.* | *Cal.* | *Cal.* | | |
| 2 | 1-25-27 | 25 | 2 | 51.0 | 158 | 74 | 183 | 1272 | 35.3 | − 4.4 | − 3.8 |
| | 1-26-27 | 25 | 2 | 51.0 | 158 | 77 | 172 | 1196 | 33.2 | −10.2 | − 9.6 |
| | 1-27-27 | 25 | 2 | 51.0 | 158 | 74 | 189 | 1313 | 36.5 | − 1.4 | − 0.7 |
| | 1-31-27 | 25 | 2 | 51.0 | 158 | 73 | 176 | 1221 | 33.9 | − 8.3 | − 7.6 |
| | 2- 1-27 | 25 | 2 | 51.0 | 158 | 66 | 177 | 1226 | 34.1 | − 7.9 | − 7.3 |
| | 2- 2-27 | 25 | 2 | 51.0 | 158 | 69 | 180 | 1252 | 34.8 | − 5.9 | − 5.3 |
| | 2- 3-27 | 25 | 2 | 51.0 | 158 | 68 | 183 | 1270 | 35.3 | − 4.6 | − 3.4 |
| | 2- 4-27 | 25 | 2 | 51.0 | 158 | 69 | 182 | 1262 | 35.1 | − 5.2 | − 4.5 |
| | 2- 5-27 | 25 | 2 | 51.0 | 158 | 73 | 196 | 1363 | 37.9 | + 2.3 | + 3.1 |
| | 2- 7-27 | 25 | 2 | 51.0 | 158 | 70 | 188 | 1305 | 36.2 | − 2.0 | − 1.3 |
| | 2- 8-27 | 25 | 2 | 51.0 | 158 | 66 | 180 | 1247 | 34.6 | − 6.3 | − 5.7 |
| | 2- 9-27 | 25 | 2 | 51.0 | 158 | 71 | 170 | 1181 | 32.8 | −11.3 | −10.7 |
| | 2-10-27 | 25 | 2 | 51.0 | 158 | 71 | 181 | 1257 | 34.9 | − 5.6 | − 4.9 |
| | 2-11-27 | 25 | 2 | 51.0 | 158 | 74 | 183 | 1268 | 35.2 | − 4.7 | − 4.1 |
| | 2-12-27 | 25 | 2 | 49.9 | 158 | 69 | 178 | 1236 | 34.6 | − 6.5 | − 5.8 |
| | 2-15-27 | 25 | 2 | 49.9 | 158 | 68 | 178 | 1240 | 34.7 | − 6.2 | − 5.5 |
| | 2-16-27 | 25 | 2 | 49.9 | 158 | 74 | 181 | 1260 | 35.2 | − 4.7 | − 4.0 |
| | 2-17-27 | 25 | 2 | 49.9 | 158 | 71 | 182 | 1266 | 35.4 | − 4.2 | − 3.5 |
| | 2-18-27 | 25 | 2 | 49.9 | 158 | 77 | 191 | 1329 | 37.2 | + 0.5 | + 1.3 |
| | 2-19-27 | 25 | 3 | 49.9 | 158 | 76 | 179 | 1241 | 34.7 | − 6.1 | − 5.4 |
| | 2-21-27 | 25 | 3 | 49.9 | 158 | 75 | 186 | 1295 | 36.2 | − 2.1 | − 1.3 |
| | 2-23-27 | 25 | 3 | 50.6 | 158 | 70 | 183 | 1271 | 35.3 | − 4.6 | − 3.6 |
| | 2-24-27 | 25 | 3 | 50.6 | 158 | 76 | 183 | 1275 | 35.4 | − 4.3 | − 3.3 |
| | 2-26-27 | 25 | 3 | 50.6 | 158 | 70 | 178 | 1240 | 34.4 | − 6.9 | − 6.0 |
| | 2-28-27 | 25 | 3 | 50.6 | 158 | 72 | 178 | 1235 | 34.3 | − 7.2 | − 6.3 |
| Average of 25 observations | | | | | | | 174 | 1261 | 35.1 | − 5.1 | − 4.4 |
| 3 | 4- 5-27 | 22 | 0 | 46.3 | 157 | 59 | 177 | 1230 | 35.8 | − 3.1 | − 4.2 |
| | 4- 7-27 | 22 | 0 | 46.3 | 157 | 65 | 171 | 1185 | 34.5 | − 6.6 | − 7.7 |
| | 4-12-27 | 22 | 0 | 46.3 | 157 | 75 | 171 | 1185 | 34.5 | − 6.6 | − 7.8 |
| | 4-13-27 | 22 | 0 | 46.3 | 157 | 64 | 165 | 1143 | 33.3 | −10.0 | −11.0 |
| | 4-20-27 | 22 | 0 | 46.3 | 157 | 65 | 166 | 1151 | 33.5 | − 9.3 | −10.4 |
| | 4-21-27 | 22 | 0 | 46.3 | 157 | 79 | 187 | 1301 | 37.9 | + 2.5 | + 1.3 |
| | 4-22-27 | 22 | 0 | 46.3 | 157 | 70 | 170 | 1181 | 34.4 | − 7.0 | − 8.1 |
| | 4-26-27 | 22 | 0 | 46.3 | 157 | 67 | 160 | 1114 | 32.5 | −12.2 | −13.2 |
| | 4-27-27 | 22 | 0 | 46.3 | 157 | 70 | 166 | 1150 | 33.5 | − 9.4 | −10.5 |
| | 4-28-27 | 22 | 0 | 46.3 | 157 | 71 | 164 | 1138 | 33.2 | −10.4 | −11.4 |
| | 5- 2-27 | 22 | 1 | 46.3 | 157 | 74 | 176 | 1221 | 35.6 | − 3.8 | − 5.0 |
| | 5- 3-27 | 22 | 1 | 46.3 | 157 | 58 | 161 | 1119 | 32.6 | −11.8 | −12.9 |
| | 5- 4-27 | 22 | 1 | 46.3 | 157 | 67 | 163 | 1135 | 33.1 | −10.6 | −11.6 |
| | 5- 5-27 | 22 | 1 | 46.3 | 157 | 64 | 171 | 1188 | 34.6 | − 6.4 | − 7.6 |
| | 5- 6-27 | 22 | 1 | 46.3 | 157 | 63 | 161 | 1121 | 32.6 | −11.7 | −12.8 |
| | 5-17-27 | 22 | 1 | 46.7 | 157 | 56 | 172 | 1195 | 34.6 | − 6.5 | − 7.2 |
| | 5-19-27 | 22 | 1 | 46.7 | 157 | 58 | 169 | 1176 | 34.0 | − 8.0 | − 8.7 |
| | 5-20-27 | 22 | 1 | 46.7 | 157 | 60 | 170 | 1181 | 34.2 | − 7.6 | − 8.3 |
| | 5-23-27 | 22 | 1 | 47.2 | 157 | 53 | 165 | 1146 | 33.2 | −10.4 | −11.4 |
| | 5-24-27 | 22 | 1 | 47.2 | 157 | 58 | 164 | 1137 | 32.9 | −11.1 | −12.1 |
| | 5-25-27 | 22 | 1 | 47.2 | 157 | 57 | 159 | 1104 | 31.9 | −13.7 | −14.6 |
| | 5-26-27 | 22 | 1 | 47.2 | 157 | 65 | 179 | 1245 | 36.0 | − 2.7 | − 3.7 |
| | 5-27-27 | 22 | 1 | 47.2 | 157 | 62 | 172 | 1192 | 34.5 | − 6.8 | − 7.8 |
| | 5-31-27 | 22 | 2 | 47.2 | 157 | 61 | 174 | 1208 | 35.0 | − 5.5 | − 6.6 |
| | 6- 1-27 | 22 | 2 | 47.2 | 157 | 73 | 192 | 1331 | 38.5 | + 4.0 | + 2.9 |
| | 6- 2-27 | 22 | 2 | 47.2 | 157 | 62 | 164 | 1138 | 32.9 | −11.0 | −12.0 |
| | 6- 3-27 | 22 | 2 | 47.2 | 157 | 62 | 172 | 1194 | 34.5 | − 6.7 | − 7.7 |
| Average | | | | | | | 170 | 1178 | 34.2 | − 7.5 | − 8.5 |

**TABLE 2.—Day by Day Variations in Basal Metabolism of Young Women—Concluded**

| Subject No. | Date of observation | Age | | Weight | Height | Pulse rate | Oxygen consumed | Heat production per 24 hr. | Heat production per sq. m. per hr. | Deviation of actual from predicted: Aub-Du Bois prediction | Deviation of actual from predicted: Harris-Benedict prediction |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Yr. | Mo. | Kg. | Cm. | | cc. | Cal. | Cal. | | |
| 4 | 2- 9-27 | 20 | 9 | 62.1 | 161 | 71 | 194 | 1345 | 34.0 | − 8.1 | − 7.1 |
| | 2-10-27 | 20 | 9 | 62.1 | 161 | 76 | 200 | 1389 | 35.1 | − 5.1 | − 4.1 |
| | 2-16-27 | 20 | 9 | 62.6 | 161 | 71 | 186 | 1295 | 32.5 | −12.1 | −10.9 |
| | 2-17-27 | 20 | 9 | 62.6 | 161 | 70 | 190 | 1321 | 33.2 | −10.3 | − 9.1 |
| | 2-18-27 | 20 | 9 | 62.6 | 161 | 69 | 184 | 1279 | 32.1 | −13.1 | −11.9 |
| | 2-19-27 | 20 | 9 | 62.6 | 161 | 67 | 202 | 1404 | 35.2 | − 4.7 | − 3.4 |
| | 2-21-27 | 20 | 9 | 62.6 | 161 | 77 | 204 | 1420 | 35.6 | − 3.6 | − 2.3 |
| | 2-23-27 | 20 | 9 | 62.6 | 161 | 75 | 171 | 1185 | 29.7 | −19.6 | −18.5 |
| | 2-24-27 | 20 | 9 | 62.1 | 161 | 74 | 217 | 1507 | 38.0 | + 3.6 | + 4.1 |
| | 2-25-27 | 20 | 9 | 62.1 | 161 | 74 | 185 | 1289 | 32.5 | −11.9 | −11.0 |
| | 2-26-27 | 20 | 9 | 62.1 | 161 | 75 | 200 | 1389 | 35.1 | − 5.1 | − 4.1 |
| | 2-28-27 | 20 | 9 | 62.1 | 161 | 73 | 195 | 1355 | 34.2 | − 7.4 | − 6.4 |
| | 3- 1-27 | 20 | 9 | 62.1 | 161 | 70 | 195 | 1352 | 34.1 | − 7.6 | − 6.7 |
| | 3- 2-27 | 20 | 9 | 62.1 | 161 | 71 | 196 | 1362 | 34.4 | − 6.9 | − 5.9 |
| | 3- 3-27 | 20 | 10 | 62.1 | 161 | 73 | 194 | 1350 | 34.1 | − 7.8 | − 6.8 |
| | 3- 4-27 | 20 | 10 | 62.1 | 161 | 73 | 184 | 1291 | 32.3 | −12.5 | −11.6 |
| | 3- 5-27 | 20 | 10 | 62.1 | 161 | 76 | 198 | 1374 | 34.7 | − 6.1 | − 5.1 |
| | 3- 7-27 | 20 | 10 | 62.1 | 161 | 72 | 189 | 1315 | 33.2 | −10.1 | − 9.2 |
| | 3- 9-27 | 20 | 10 | 62.1 | 161 | 74 | 206 | 1431 | 36.1 | − 2.2 | − 1.2 |
| | 3-10-27 | 20 | 10 | 62.1 | 161 | 75 | 188 | 1307 | 33.0 | −10.7 | − 9.8 |
| | 3-11-27 | 20 | 10 | 62.1 | 161 | 76 | 203 | 1408 | 35.6 | − 3.8 | − 2.8 |
| | 3-12-27 | 20 | 10 | 62.1 | 161 | 75 | 189 | 1314 | 33.2 | −10.2 | − 9.3 |
| | 3-14-27 | 20 | 10 | 62.1 | 161 | 76 | 194 | 1351 | 34.1 | − 7.7 | − 6.7 |
| | Average | | | | | | 194 | 1349 | 34.0 | − 8.0 | − 6.9 |
| 5 | 4- 2-27 | 21 | 7 | 56.4 | 155 | 75 | 202 | 1403 | 38.0 | + 2.5 | + 1.4 |
| | 4- 4-27 | 21 | 7 | 56.4 | 155 | 67 | 197 | 1370 | 37.1 | 0.0 | − 1.0 |
| | 4- 7-27 | 21 | 7 | 56.4 | 155 | 66 | 191 | 1329 | 36.0 | − 2.8 | − 4.0 |
| | 4- 9-27 | 21 | 7 | 56.4 | 155 | 69 | 196 | 1364 | 36.9 | − 0.3 | − 1.5 |
| | 4-11-27 | 21 | 8 | 56.4 | 155 | 71 | 207 | 1441 | 39.0 | + 5.3 | + 4.1 |
| | 4-13-27 | 21 | 8 | 56.4 | 155 | 70 | 193 | 1341 | 36.3 | − 1.9 | − 3.1 |
| | 4-14-27 | 21 | 8 | 56.4 | 155 | 58 | 193 | 1338 | 36.2 | − 2.1 | − 3.3 |
| | 4-15-27 | 21 | 8 | 56.4 | 155 | 66 | 183 | 1270 | 34.4 | − 7.2 | − 8.3 |
| | 4-16-27 | 21 | 8 | 56.4 | 155 | 75 | 194 | 1350 | 36.5 | − 1.3 | − 2.4 |
| | 4-18-27 | 21 | 8 | 56.4 | 155 | 70 | 196 | 1361 | 36.8 | − 0.4 | − 1.6 |
| | 4-19-27 | 21 | 8 | 56.4 | 155 | 64 | 200 | 1392 | 37.7 | + 1.8 | + 0.6 |
| | 4-20-27 | 21 | 8 | 55.8 | 155 | 69 | 193 | 1339 | 36.2 | − 2.1 | − 2.8 |
| | 4-21-27 | 21 | 8 | 55.8 | 155 | 63 | 187 | 1297 | 35.1 | − 5.1 | − 5.8 |
| | 4-22-27 | 21 | 8 | 55.8 | 155 | 71 | 190 | 1322 | 35.8 | − 4.8 | − 4.1 |
| | 4-23-27 | 21 | 8 | 55.8 | 155 | 62 | 195 | 1355 | 36.7 | − 2.5 | − 1.7 |
| | 4-25-27 | 21 | 8 | 55.8 | 155 | 65 | 192 | 1333 | 36.1 | − 2.5 | − 3.3 |
| | 4-26-27 | 21 | 8 | 65.8 | 155 | 71 | 192 | 1332 | 36.0 | − 2.6 | − 3.3 |
| | 4-27-27 | 21 | 8 | 55.8 | 155 | 69 | 195 | 1357 | 36.7 | − 0.8 | − 1.6 |
| | 4-28-27 | 21 | 8 | 55.8 | 155 | 60 | 186 | 1291 | 34.9 | − 5.5 | − 6.3 |
| | 4-29-27 | 21 | 8 | 55.8 | 155 | 64 | 193 | 1338 | 36.2 | − 2.1 | − 2.9 |
| | 5- 2-27 | 21 | 8 | 55.3 | 155 | 72 | 192 | 1334 | 36.3 | − 1.8 | − 2.7 |
| | 5- 3-27 | 21 | 8 | 55.3 | 155 | 63 | 194 | 1347 | 36.7 | − 0.8 | − 1.7 |
| | 5- 4-27 | 21 | 8 | 55.3 | 155 | 65 | 186 | 1293 | 35.2 | − 4.8 | − 5.6 |
| | 5- 5-27 | 21 | 8 | 55.3 | 155 | 63 | 197 | 1368 | 37.2 | + 0.7 | − 0.2 |
| | 5- 6-27 | 21 | 8 | 55.3 | 155 | 65 | 203 | 1413 | 38.5 | + 4.0 | + 3.1 |
| | 5- 7-27 | 21 | 8 | 55.3 | 155 | 51 | 193 | 1341 | 36.5 | − 1.2 | − 2.1 |
| | 5-10-27 | 21 | 8 | 55.3 | 155 | 63 | 200 | 1387 | 37.8 | + 2.1 | + 1.2 |
| | 5-11-27 | 21 | 9 | 55.3 | 155 | 60 | 197 | 1365 | 37.2 | + 0.5 | − 0.4 |
| | 5-12-27 | 21 | 9 | 55.3 | 155 | 60 | 191 | 1329 | 36.2 | − 3.8 | − 3.0 |
| | 5-16-27 | 21 | 9 | 54.9 | 155 | 62 | 187 | 1297 | 35.3 | − 4.4 | − 5.3 |
| | 5-17-27 | 21 | 9 | 54.9 | 155 | 67 | 192 | 1337 | 36.4 | − 1.5 | − 2.4 |
| | 5-18-27 | 21 | 9 | 54.9 | 155 | 54 | 196 | 1358 | 37.0 | 0.0 | − 0.9 |
| | 5-19-27 | 21 | 9 | 54.9 | 155 | 66 | 189 | 1309 | 35.7 | − 3.6 | − 4.4 |
| | 5-20-27 | 21 | 9 | 54.9 | 155 | 57 | 191 | 1326 | 36.1 | − 2.3 | − 3.2 |
| | 5-23-27 | 21 | 9 | 54.9 | 155 | 63 | 201 | 1393 | 37.9 | + 2.5 | + 1.7 |
| | 5-24-27 | 21 | 9 | 54.9 | 155 | 62 | 199 | 1380 | 37.6 | + 1.6 | + 0.7 |
| | 5-25-27 | 21 | 9 | 54.9 | 155 | 56 | 196 | 1364 | 37.2 | + 0.4 | − 0.4 |
| | 5-27-27 | 21 | 9 | 54.4 | 155 | 53 | 200 | 1392 | 38.2 | + 3.0 | + 2.0 |
| | 5-31-27 | 21 | 9 | 54.4 | 155 | 66 | 201 | 1399 | 38.4 | + 3.5 | + 2.5 |
| | 6- 1-27 | 21 | 9 | 54.4 | 155 | 63 | 188 | 1303 | 35.7 | − 3.5 | − 4.5 |
| | 6- 2-27 | 21 | 9 | 54.4 | 155 | 62 | 192 | 1335 | 36.6 | − 1.1 | − 2.2 |
| | 6- 3-27 | 21 | 9 | 54.4 | 155 | 57 | 202 | 1401 | 38.4 | + 3.7 | + 2.7 |
| | Average of 42 observations | | | | | | 194 | 1350 | 36.7 | − 1.0 | − 1.8 |

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